Acc 89

TECHNICAL MANUAL

OPERATION AND SERVICE INSTRUCTIONS
WITH ILLUSTRATED PARTS BREAKDOWN

VACUUM TUBE VOLTMETER

MODELS 400D/DR, 400H/HR, 400L/LR, C10-400D/DR, C12-400DR
PART NO. A11112-001

(HEWLETT-PACKARD)
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1-2	4				
1-3	3				
1-4 Blank	3				
2-1	0				
3-0 thru 3-5	0				
4-0	0				
4-1	2				
4-2 thru 4-3	0				
4-4 Blank	0				
5-1 thru 5-12	0				
6-1 thru 6-4	0				
7-1 thru 7-11	0				
7-12 Blank	0				
8-1 thru 8-2	0				
9-1	0				
9-2 Blank	0				
10-1 thru 10-2	0				
11-1 thru 11-2	3				
12-1	1				
12-2 Blank	1				
13-1	1				
13-2 Blank	1				
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14-5 thru 14-10 Added	4				

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TABLE OF CONTENTS

Section			Page
I	GENERAL DESCRIPTION		1-1
	1-1	Introduction	1-1
	1-4	Description	1-2
	1-10	Accessories	1-2
II	INSTALLATION		2-1
	2-1	Unpacking and Inspection	2-1
	2-3	Line Voltage Requirement	2-1
	2-5	Power Line Connections	2-1
	2-8	Installation	2-1
	2-10	Operation Check	2-1
III	OPERATING INSTRUCTIONS		3-1
	3-1	Instrument Turn-On	3-1
	3-3	General Operating Information	3-1
	3-12	Low-Level Measurements and Ground Currents	3-2
	3-14	Measurement of Voltage	3-2
	3-17	Measurement of Decibels	3-3
	3-20	Impedance Correction Graph	3-3
	3-22	Use of Voltmeter Amplifier	3-4
IV	CIRCUIT DESCRIPTION		4-1
	4-1	Block Diagram	4-1
	4-3	Input Voltage Divider and Step Attenuator	4-1
	4-7	Broadband Voltmeter Amplifier	4-1
	4-10	Indicating Meter Circuit	4-1
	4-14	Power Supply	4-2
V	MAINTENANCE		5-1
	5-1	Scope	5-1
	5-3	Precautions	5-1
	5-5	Test Equipment Required	5-1
	5-7	Meter Zero Adjustment	5-2
	5-9	Cabinet Removal	5-2
	5-10	Tube Replacement	5-2
	5-13	Replacement of Special Parts	5-2
	5-17	Troubleshooting	5-3
	5-20	Testing the Power Supply	5-3
	5-22	Testing Voltmeter Performance	5-7
	5-24	Calibration and Frequency Response Adjustments	5-9
VI	ILLUSTRATED PARTS BREAKDOWN		6-1
	6-1	General	6-1
VII	GROUP ASSEMBLY PARTS LIST		7-1
VIII	NUMERICAL INDEX		8-1
IX	REFERENCE DESIGNATION INDEX		9-1
X	DIFFERENCE DATA SHEET		10-1
	Vacuum Tube Voltmeter, Electronics Division of General Dynamics, Part Number A11112-001		10-1
XI	DIFFERENCE DATA SHEET		11-1
	Vacuum Tube Voltmeter, Model 400D/DR serial number 310-45570 and below, Models 400H/HR and 400L/LR serial number 313-22176 and below, Models 400L/LR serial number 048-132560 and below, models 400H/HR serial number 017-12026 and below		11-1
XII	DIFFERENCE DATA SHEET		12-1
	Vacuum Tube Voltmeter Model C10-400D/DR		12-1
XIII	DIFFERENCE DATA SHEET.		13-1
	Vacuum Tube Voltmeter, Model C12-400DR		13-1
XIV	DIFFERENCE DATA SHEET.		14-1
	Vacuum Tube Voltmeter Models 400D, 400H, and 400L, Test, Adjustment, and Certification Methods		14-1

LIST OF ILLUSTRATIONS

Number	Title	Page
1-1	Vacuum Tube Voltmeters Models 400D/DR, 400H/HR and 400L/LR	1-0
1-2	Table of Specifications	1-1
3-1	Voltmeter Front Panel, Showing Controls and Connectors	3-0
3-2	Effect of Harmonics on Voltage Measurements	3-1
3-3	Test Setup for Avoiding Ground Loop	3-2
3-4	Impedance Correction Graph	3-5
4-1	Voltmeter Block Diagram	4-0
4-2	Simplified Schematic of Meter Bridge Circuit	4-2
5-1	Test Equipment Required	5-1
5-2	Adjustments Required When Tubes Are Replaced	5-2
5-3	Left Side View of Voltmeter Chassis	5-4
5-4	Right Side View of Voltmeter Chassis	5-5
5-5	Trouble-Shooting Procedure	5-6
5-6	Test Setup for Calibration Check and Adjustments	5-7
5-7	Test Setup for Frequency Response Check and Adjustment	5-8
5-8	Voltage and Resistance Diagram	5-10
5-9	Diagram of RANGE Switch	5-11
5-10	Voltmeter Schematic Diagram	5-13
7-1	Model 400 Vacuum Tube Voltmeter Series	7-1
7-2	Main Chassis Assembly	7-3
7-3	RANGE Switch Assembly	7-7
7-4	Printed Circuit Board Assembly Part No. 400D-75G	7-9
7-5	Printed Circuit Board Assembly Part No. 400D-75F	7-10
7-6	Printed Circuit Board Assembly Part No. 400D-65C	7-11
10-1	Voltmeter A11112-001	10-2
11-1	Power Transformer T1	11-1
14-1	Schematic Diagram With "Capacitive Input Divider" Circuit, Original Feedback Circuit, and Original Power Supply Circuit	14-7
14-2	Schematic Diagram With "Resistive Input Divider" Circuit, Revised Feedback Circuit, and Modified Power Supply Circuit	14-8
14-3	Schematic Diagram Models 400D/H/L With Serials Prefixed 017- or 048-	14-9

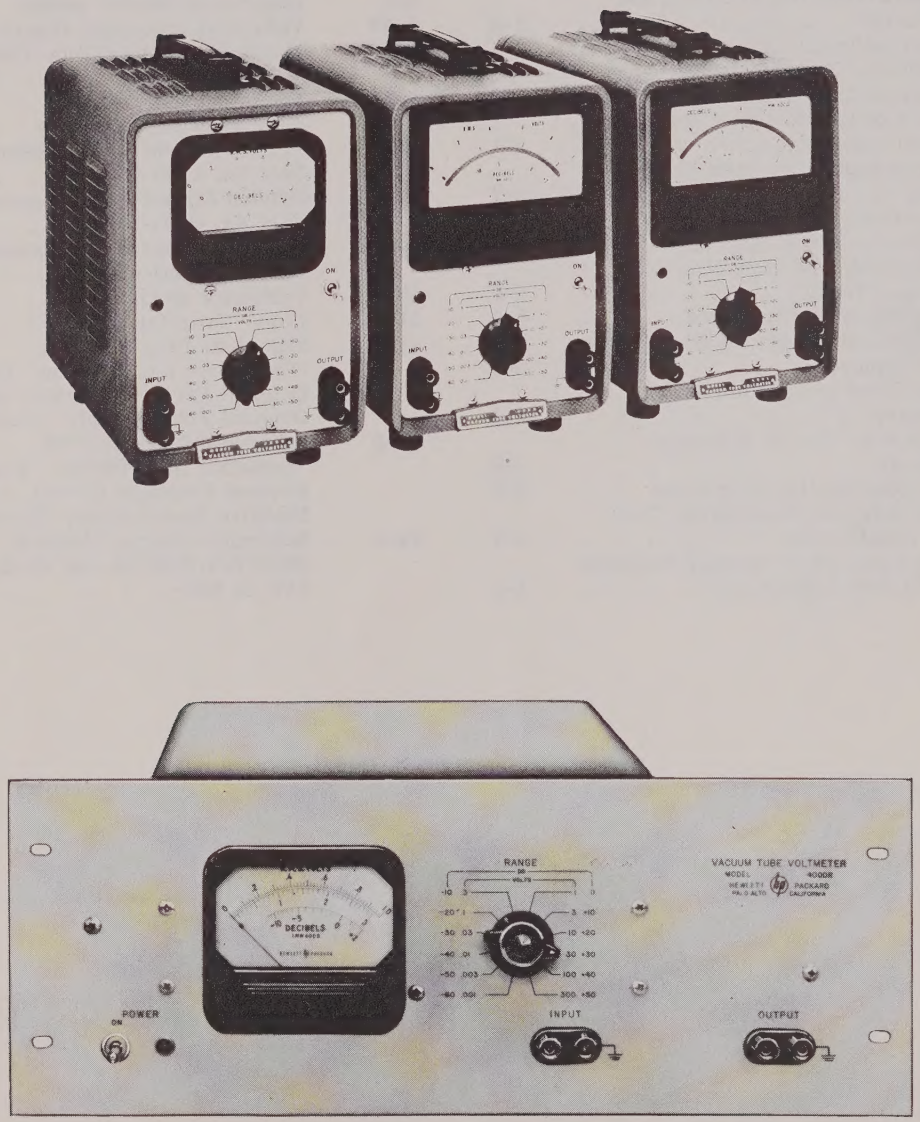

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Figure 1-1. Vacuum Tube Voltmeter Models 400D/DR, 400H/HR, and 400L/LR

SECTION I
GENERAL DESCRIPTION

1—1. INTRODUCTION (See figure 1-1.)

1-2. This manual is a Hewlett-Packard Company commercial manual revised to meet government commercial manual requirements. Sections I through IX provide operation and service instructions and a parts breakdown for the following Vacuum Tube Voltmeters manufactured by the Hewlett-Packard Company.

a. Models 400D/DR having serial numbers 310-45571 and above

b. Models 400H/HR having serial numbers 313-22177 and above

c. Models 400L/LR having serial numbers 313-22177 and above

Section X contains difference data necessary to adapt this manual to Model 400DR Vacuum Tube Voltmeter modified to the specification of General Dynamics/ Electronics part number A11112-001. Section XI contains difference data necessary to adapt this manual to other instruments as follows:

a. Model 400D/DR having serial number 310-45570 and below

b. Models 400 H/HR and 400 L/LR having serial numbers 313-22176 and below

a. Voltage Range: 0:1 millivolt to 300 volts in 12 ranges providing full scale readings of the following voltages:

0.001	0.100	10.00
0.003	0.300	30.00
0.010	1.000	100.00
0.030	3.000	300.00

b. Decibel Range: -72 to +52 db, in 12 ranges.

c. Frequency Range: 10 cps to 4 mc.

d. Input Impedance: 10 megohms shunted by 15 pf (15 $\mu\mu$f) on ranges 1.0 volt to 300 volts; 25 pf on ranges 0.001 volt to 0.3 volt.

e. Stability: Line voltage variations of ±10% do not reduce the specified accuracy, and line voltage transients are not reflected in the meter reading. Electron tube deterioration to 75% of normal transconductance affects accuracy less than 0.5% from 20 cps to 1 mc.

f. Amplifier: OUTPUT terminals are provided so that the voltmeter can be used to amplify small signals or to enable monitoring of waveforms under test with an oscilloscope. Output voltage is approximately 0.15 volt rms on all ranges with full-scale meter deflection. Amplifier frequency response is same as the voltmeter. Internal impedance is approximately 50 ohms over entire frequency range.

g. Accuracy: Model 400D -

±2% of full scale, 20 cps to 1 mc;
±3% of full scale, 20 cps to 2 mc;
±5% of full scale, 10 cps to 4 mc.

Model 400H -

±1% of full scale, 50 cps to 500 kc;
±2% of full scale, 20 cps to 1 mc;
±3% of full scale, 20 cps to 2 mc;
±5% of full scale, 10 cps to 4 mc.

Model 400L -

±2% of reading or ±1% of full scale, whichever is more accurate, 50 cps to 500 kc.
±3% of reading or ±2% of full scale, whichever is more accurate, 20 cps to 1 mc.
±4% of reading or ±3% of full scale, whichever is more accurate, 20 cps to 2 mc.
±5% of reading 10 cps to 4 mc.

h. Power Requirement: 115/230 volts ±10%, 50/1000 cps, approximately 80 watts.

i. Size: 11-3/4 in. high, 7-1/2 in. wide, 12 in. deep.

j. Weight: 18 lbs; shipping weight approximately 23 lbs.

Figure 1-2. Table of Specifications

c. Models 400 L/LR having serial numbers 048-13256 and below

d. Models 400 H/HR having serial numbers 017-12026 and below

Section XII contains difference data necessary to adapt this manual to Model C10-400D/DR Vacuum Tube Voltmeter. Section XIII contains difference data necessary to adapt this manual to Model C12-400DR Vacuum Tube Voltmeter. Section XIV contains difference data for Models 400D, 400H, and 400L to add supplementary information for Test, Adjustment, and Certification Methods. Section XIV covers item changes which refer to specific serial numbers. These data should be referred to whenever Test, Adjustment, or Certification is performed on these models.

1-3. The Models 400D, 400H, and 400L Voltmeters are the same except as follows:

a. The front panel meters are different in each model, as described in paragraph 1-6.

b. The accuracy specifications are different for each model, as described in figure 1-2.

Instruments designated Models 400DR, 400HR, and 400LR are rack mount configurations of the 400D, 400H, and 400L, respectively. They are identical to their cabinet model counterparts in every other respect. They are designed to be mounted in a standard 19 inch wide by 7 inch high relay rack space.

Recommendations proposing changes to this manual shall be submitted on AFTO Form 22, in accordance with T.O. 00-5-1, to the following addressee:

AFPRO GD/CAD (QAE) ATTN: CTOCU
P.O. Box 371
Fort Worth, Texas 76101

1-4. DESCRIPTION.

1-5. The Hewlett-Packard Models 400D, 400H, and 400L Vacuum Tube Voltmeters are general purpose, portable electronic a-c voltmeters of high sensitivity and stability. They are suited to both laboratory and field use. All three voltmeter models measure a-c voltages from 0.001 to 300 volts rms full scale, with a frequency bandwidth covering 10 cps to 4 megacycles. The voltmeters are compact, accurate, and rugged and have fast meter response, high input impedance, stable calibration accuracy, and freedom from the effects of normal line voltage variations. The voltmeters are designed for long instrument life with a minimum of servicing.

1-6. Each model voltmeter has three calibrated scales on the panel meter. The Models 400D and 400H have two linear VOLTS scales, 0 to 1 and 0 to 3, and one DECIBELS scale, -12 to +2 db. The meters used in the Models 400H and 400L are larger and include a mirror to eliminate parallax in viewing and to facilitate use of the higher scale calibration accuracy of these models. The Model 400L VOLTS scales are logarithmic in calibration, from 0.3 to 1 and 0.8 to 3; and the DECIBELS scale is linear. In all models, the VOLTS scales are calibrated to indicate the root-mean-square (rms) value of an applied sine wave. Actual meter deflection is proportional to the average value of the applied signal, thereby minimizing additional meter deflection due to noise and harmonic distortion.

1-7. A voltmeter output signal is provided at the front panel OUTPUT terminals. This output is proportional to the meter reading and has a waveshape similar to the applied signal. This signal level is about 0.15 volts rms for a full-scale meter reading, regardless of the input signal level. The internal impedance at the OUTPUT terminal is 50 ohms over the full frequency range. High-impedance loads (above 100K) will not adversely affect the accuracy of the voltmeter. This output is valuable for increasing the sensitivity of bridges, etc., where distortion added to the waveform is not a factor.

1-8. The voltmeter chassis is constructed of aluminum alloy throughout. The panel is finished in nonreflecting, light-grey baked enamel; the cabinet is finished in dark-grey, baked wrinkle paint. The cabinet is equipped with rubber feet and a leather carrying handle. Control narkings on the front panel are engraved and black filled. INPUT and OUTPUT terminals are special binding posts which accept either bare wire or banana plugs; the 3/4-inch spacing between binding posts accepts standard dual-banana plugs. The "ground" side of the INPUT and OUTPUT terminals is connected to the instrument chassis which is in turn connected to the power line ground through the third (round) prong of the plug on the power cable.

1-9. The voltmeter is equipped with a non-detachable power cord. Test leads, which may be plain wire leads or coaxial cable, and test probes must be supplied by the user.

1-10. ACCESSORIES.

1-11. Accessory instruments for the voltmeter are available (not supplied) to increase its range of operation and application, such as increasing voltage measurement range and input impedance, converting to current measurement, providing line matching, etc., as follows:

a. H-P AC-60A/11004A Line Matching Transformer. Provides balanced 135-ohm or 600-ohm input, 5 kc to 600 kc.

b. H-P AC-60B/11005A Bridging Transformer. Allows voltage measurement on balanced lines. 20 cps to 45 kc.

c. H-P 452A/11039A Capacitive Voltage Divider. Safely measures power-frequency voltages to 25 kilovolts. Division ratio, 1000:1. Input capacity, 15 pf ±1 pf.

d. H-P 454A/11041A Capacitive Voltage Divider. Accuracy ±3%. Division ratio, 100:1. Input impedance, 50 megohms, resistive, shunted with 2.75 pf capacity. Maximum voltage, 1500 volts.

e. H-P 456A AC Current Probe. Allows current measurements without breaking the circuit. Sensitivity 1 mv/ma ±2% at 1 kc. Maximum input 1 amp rms; 2 amp peak. Output noise less than 50μv rms.

f. H-P 470A/11029A, 470F/11034A Shunt Resistors. For measuring currents as small as 1 microamp full scale. Accuracy ±1% to 100 kc, ±5% to 4 mc (470A, ±5% to 1 mc). Maximum power dissipation, 1 watt.

SECTION II
INSTALLATION

2-1. UNPACKING AND INSPECTION.

2-2. There are no special precautions for unpacking the voltmeter. Save the shipping carton and packing materials for possible storage or reshipment. When unpacking, inspect instrument and packing materials for signs of damage in shipment. Make an operation check as directed in paragraph 2-10 to determine if performance is satisfactory. If there is any indication of damage, immediately file a claim with the transport service used or other cognizant authority.

2-3. LINE VOLTAGE REQUIREMENT.

2-4. The voltmeter is wired at the factory for use on 115-volt a-c power. This voltage may vary ±10% without adverse effect upon voltmeter performance. The voltmeter can be wired for use on 230-volt a-c power by reconnecting the dual primary windings on the power transformer as shown in the schematic diagram in Section V. When using 230-volt power, change from a 1-amp to a 1/2-amp slow-blow fuse. If necessary, provide an adapter for attaching the standard 115-volt plug on the voltmeter to the 230-volt outlet.

2-5. POWER LINE CONNECTION.

2-6. The three-conductor power cable on the voltmeter is terminated in a polarized three-prong male connector. The third contact is an offset round pin added to a standard two-blade connector, which grounds the instrument chassis when used with the appropriate receptacle. To connect this plug in a standard two-contact receptacle, use an adapter. The chassis ground connection is brought out of the adapter in a green pigtail lead for connection to a suitable ground.

2-7. The power plug normally supplied with the voltmeter is made of molded rubber and is an integral part of the power cable. On certain military contracts, a modification of the Model 400D, termed the H02-400D, is equiped with a removable plug having the same pin configuration but constructed of corrosion-resistant material. In all other respects the H02-400D is the same as the Model 400D and carries the same Federal Stock Number.

WARNING

The lower INPUT and OUTPUT signal terminals on the panel of the voltmeter are connected directly to the chassis of the voltmeter. Any voltage applied to the lower terminal will be shorted directly to ground. If the ground connection in the power cord is disconnected by use of an adapter, the entire voltmeter cabinet will carry whatever potential is applied to the lower terminal and may be a hazard to the operator.

2-8. INSTALLATION.

2-9. The voltmeter is a portable instrument requiring no permanent installation. The voltmeter is for bench-top operation, standing on its rubber feet with its front panel near the vertical plane. A bail is provided for raising the front of the cabinet to obtain a better viewing angle.

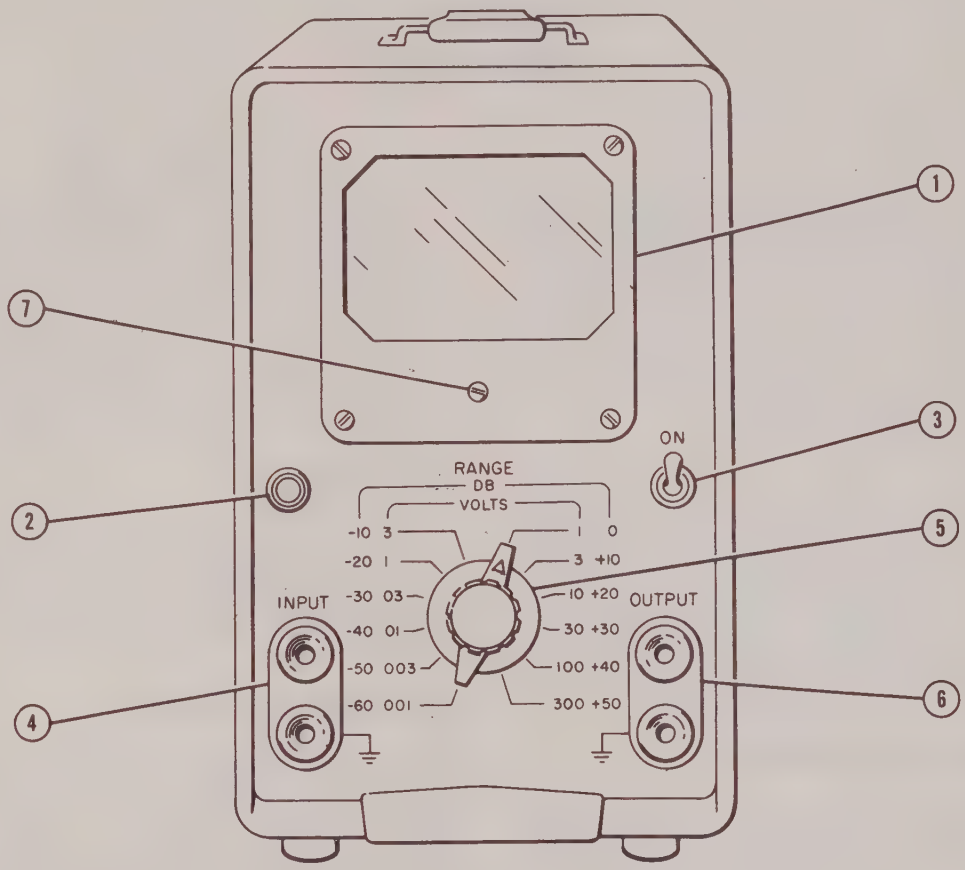
2-10. OPERATION CHECK.

2-11. The voltmeter is ready for use as received from the factory. The simple check described below can be made by incoming inspectors to determine if electrical damage was incurred in shipment. If more complete proof of instrument performance is required, the over-all performance check described in paragraph 5-22 must be used. Make a simple performance check as follows:

a. Connect voltmeter to the power line through a variable transformer. Set transformer for 115 volts, turn on and allow a five-minute warmup.

b. Measure any sine wave voltage, excepting the power line, from 0.01 to 300 volts whose exact voltage is known. Note that the lower INPUT terminal is connected to the power line ground.

c. While making the above measurement, adjust the line voltage from 103 to 127 volts. The reading on the meter must not change by more than the width of the pointer.



REFERENCE NUMBER	DESIGNATION	FUNCTION
1	Panel meter	Indicates rms volts and decibels.
2	Indicator light	Indicates that voltmeter is turned on.
3	ON Power switch	Applies line power to voltmeter.
4	INPUT terminals	Receive voltage to be measured or signal to be amplified.
5	RANGE (DB-VOLTS) switch	Selects full-scale deflection sensitivity.
6	OUTPUT terminals	Supply signal level proportional to meter reading, with same waveform as applied to INPUT terminals.
7	Zero adjust screw	Meter zero adjust screw (for 400D and 400H only).

Figure 3-1. Voltmeter Front Panel, Showing Controls and Connectors

SECTION III
OPERATING INSTRUCTIONS

3-1. INSTRUMENT TURN-ON.

3-2. The voltmeter is ready for use as received from the factory and will give specified performance after a few minutes warmup. See Section II for information regarding connection to the power source and to the voltage to be measured. Controls are shown in figure 3-1.

3-3. GENERAL OPERATING INFORMATION.

3-4. METER ZERO CHARACTERISTIC. When the Model 400D and 400H Voltmeters are turned off, the meter pointer should rest exactly on the zero calibration mark on the meter scale. If it does not, zero-set the meter as instructed in paragraph 5-7. The meter supplied in the Model 400L Voltmeter is not provided with a mechanical meter zero adjustment. When the voltmeter is turned on with the INPUT terminals shorted, the meter pointer may deflect upscale slightly; this deflection does not affect the accuracy of a reading.

NOTE

When the voltmeter RANGE switch is set to the lowest ranges and the INPUT terminals are not terminated or shielded, noise pickup can be enough to produce up to full-scale meter deflection. This condition is normal and is caused by stray voltages in the vicinity of the instrument. For maximum accuracy on the .001-volt range, the voltage under measurement should be applied to the voltmeter through a shielded test lead.

3-5. METER SCALES. The two voltage scales on each of the voltmeter models are related to each other by a factor of $1:\sqrt{10}$ (10 db). In conjunction with the calibrated RANGE switch steps, this provides an intermediate range step spaced 10 db between "power of ten" ranges, which are 20 db apart. The relationship of the DECIBELS scale to the 0 to 1 VOLT scale is determined by making 0 db on the DECIBELS scale equal to the voltage required to produce 1 milliwatt in 600 ohms (0.775 volts). Thus, the DECIBELS scale reads directly in dbm (decibels referred to one milliwatt) across a 600-ohm circuit, and can be used to measure absolute level of sine wave signals. It can also be used to measure relative levels of any group of signals which have the same waveform, across any constant circuit impedance. The RANGE switch changes voltmeter sensitivity in 10-db steps accurate to within ±1/8 db. The RANGE switch position indicates the value of a full-scale meter reading.

3-6. CONNECTIONS. Voltmeter test leads must be provided by the user. The type of leads and probes used will depend upon the application, as listed below:

a For connection to low-impedance signal sources, plain wire leads often are sufficient.

b. For high-impedance sources, or where noise pickup is a problem, low-capacity shielded wire must be used with a shielded, dual banana plug for connection to the voltmeter terminals.

c. If a probe is used, it should also be shielded to prevent pickup from the hand.

d. For signals above a few hundred kilocycles, the capacity of the test leads must be kept to a minimum by using very short leads, preferably unshielded. An alligator clip should be used at the test end so that connection can be made without adding the capacity of the user's hands.

3-7. MAXIMUM INPUT VOLTAGE. Do not apply more than 600 volts dc to the INPUT terminals. To do so exceeds the voltage rating of the input capacitor.

3-8. If an applied voltage momentarily exceeds the selected full-scale voltmeter sensitivity, a few seconds may be required for circuit recovery, but no damage will result.

3-9. INPUT VOLTAGE WAVEFORM. The voltmeter is calibrated to indicate the root-mean-square value of a sine wave; however, meter pointer deflection is proportional to the average value of whatever waveform is applied to the input. If the input signal waveform is not a sine wave, the reading will be in error by an amount dependent upon the amount and phase of the harmonics present, as shown in figure 3-2 below. When harmonic distortion is less than about 10%, the error which results is negligible.

INPUT VOLTAGE CHARACTERISTICS	TRUE RMS VALUE	METER INDICATION
Fundamental = 100	100	100
Fundamental +10% 2nd harmonic	100.5	100
Fundamental +20% 2nd harmonic	102	100-102
Fundamental +50% 2nd harmonic	112	100-110
Fundamental +10% 3rd harmonic	100.5	96-104
Fundamental +20% 3rd harmonic	102	94-108
Fundamental +50% 3rd harmonic	112	90-116

Note: This chart is universal in application since these errors are inherent in all average-responding type voltage-measuring instruments.

Figure 3-2. Effect of Harmonics on Voltage Measurements

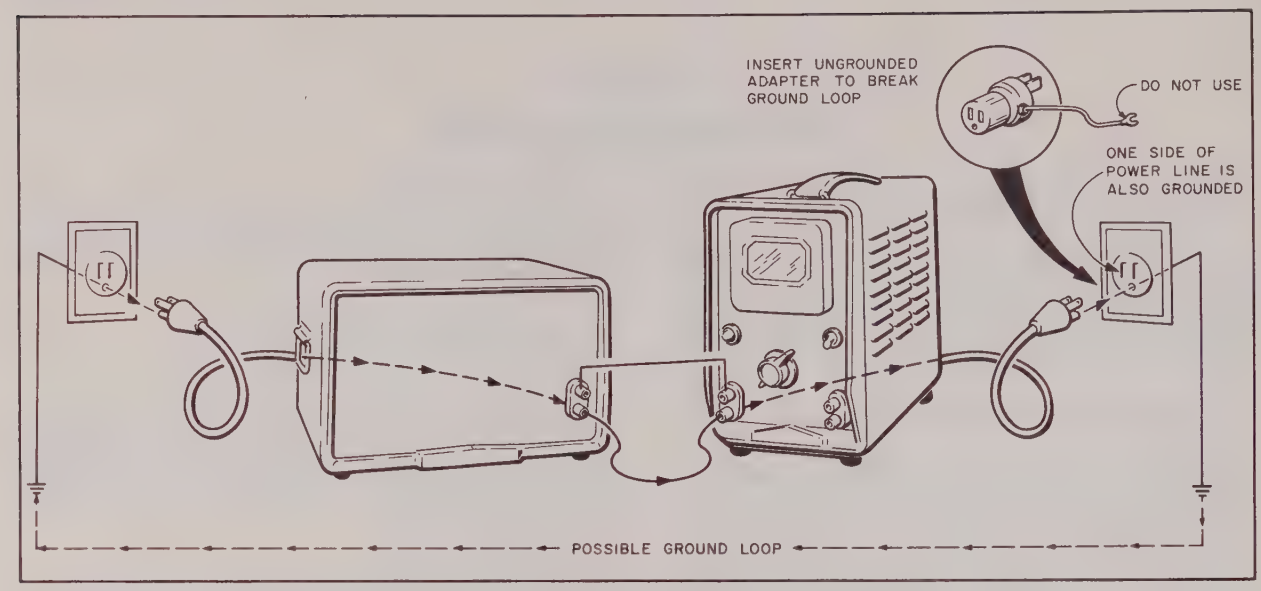


Figure 3-3. Test Setup for Avoiding Ground Loop

3-10. Since the voltmeter meter deflection is proportional to the average value of the input waveform, it is not adversely affected by moderate levels of random noise. The effect that noise has on the accuracy of the meter reading depends upon the waveform of the noise and upon the signal-to-noise ratio. A square wave has the greatest effect, a sine wave intermediate effect, and "white" noise has the least effect on the meter reading.

3-11. If the noise signal is a 50% duty cycle square wave and the signal-to-noise ratio is 10:1 (between peak voltages), the error will be about 1% of the meter reading. If the noise signal is "white" noise and the signal-to-noise ratio 10:1, the error is negligible.

3-12. LOW-LEVEL MEASUREMENTS AND GROUND CURRENTS.

3-13. When the voltmeter is used to measure signal levels below a few millivolts, ground currents in the meter test leads can cause an error in meter reading. Such currents are created when two or more ground connections are made between the instruments of a test setup and/or between the instruments and the power line ground. Two ground connections complete an electrical circuit (ground loop) for the voltages which are generated across all instrument chassis by stray fields, particularly the fields of transformers. These ground currents can be minimized by disconnecting the ground lead in the power cord from either the voltmeter or the signal source being measured, at the power outlet as shown in figure 3-3, and by making sure that in the test setup no other ground loop is formed that can cause a ground current to flow in the voltmeter test leads. Although the resultant voltage developed across a test lead is in the order of microvolts, it is enough to cause noticeable errors in measurements of a few millivolts. The presence of ground currents can sometimes be determined by simply changing the grounds for the instruments in the setup and watching for a change in meter reading. If changing the ground system causes a change in meter reading, ground currents are present.

3-14. MEASUREMENT OF VOLTAGE.

3-15. The meter has two VOLTS scales, 0 to 1 and 0 to 3. When the RANGE switch is set to .001, .01, .1, 1, 10, or 100 VOLTS, read the 0 to 1 scale. When the RANGE switch is set to .003, .03, .3, 3, 30, or 300 VOLTS, read the 0 to 3 scale.

CAUTION

The lower (black) signal INPUT and OUTPUT terminals and the instrument case are connected to the power system ground when the instrument is used with a standard three-terminal (grounding) receptacle. Connect only ground-potential circuits to the black INPUT and OUTPUT terminals.

3-16. Operate the instrument as follows:

a. Connect the voltmeter to the a-c power source.

b. Turn the Power switch ON and allow a warmup period of approximately five minutes.

c. Disconnect any external equipment from the OUTPUT terminals.

d. Set the RANGE switch to the VOLTS range which will read the voltage to be measured at mid-scale or above. If in doubt, select a higher VOLTS range.

e. Connect the voltage to be measured to the INPUT terminals.

CAUTION

AVOID A SHORT CIRCUIT ACROSS THE POWER LINE! To measure power line voltage, first connect only the upper (red) INPUT terminal to each side of the power line, in turn, leaving it connected to the side that causes meter indication. Then connect the lower (black) INPUT terminal (grounded internally) to the other side of the line. If this procedure is not followed, the power line may be short-circuited through the grounded INPUT terminal of the voltmeter.

f. Read the meter indication on the appropriate VOLTS scale, in accordance with the full-scale value indicated on the RANGE switch. Evaluate the reading in terms of the full-scale value indicated on the RANGE switch. Study the following examples:

Example 1
When the RANGE switch is in the .1 VOLTS range, read the 0 to 1 VOLTS scale. If the meter indicates .64 on that scale, the voltage being measured is:

$$.64 \text{ (meter indication)} \times \frac{.1 \left[\begin{matrix}\text{switch-selected} \\ \text{voltage range}\end{matrix}\right]}{1 \text{ (full-scale value)}} = .064 \text{ volt}$$

Example 2.
When the RANGE switch is in the 30 VOLTS range, read the 0 to 3 VOLTS scale. If the meter indicates 1.6 on that scale, the voltage being measured is:

$$1.6 \text{ (meter indication)} \times \frac{30 \left[\begin{matrix}\text{switch-selected} \\ \text{voltage range}\end{matrix}\right]}{3 \text{ (full-scale value)}} = 16 \text{ volts}$$

3-17. MEASUREMENT OF DECIBELS.

3-18. The DECIBELS meter scale is provided for measuring dbm directly across 600 ohms and for measuring db ratio for comparison purposes when each measurement is made across the same circuit impedance. To measure signal level directly in dbm (0 dbm equals 1 milliwatt into 600 ohms) proceed as follows:

a. Connect the voltmeter to the a-c power source.

b. Turn the Power switch ON and allow a warmup period of approximately five minutes.

c. Disconnect any external equipment from the OUTPUT terminals.

d. Set the RANGE switch to the DB range which will give an upscale reading of the signal to be measured. If in doubt, select a higher-level scale.

e. Connect the voltage to be measured to the INPUT terminals.

f. Note the meter indication on the DECIBELS scale (-12 to +2 db). The signal level is the algebraic sum of the meter indication and the db value indicated by the RANGE selector. Study the following examples:

Example 1
If the indication on the DECIBELS scale is +2 and the RANGE switch is in the +20 DB position, the level is +22 dbm.

Example 2
If the indication on the DECIBELS scale is +1.5 and the RANGE switch is in the -40 DB position, the level is -38.5 dbm.

3-19. To measure db across impedances other than 600 ohms, follow the above procedure and evaluate the results as follows:

NOTE

Since the measurement is made across other than 600 ohms, the level obtained in step f is in db, but not in dbm.

a. To obtain the difference in db between measurements made across equal impedances, algebraically subtract the levels being compared.

b. To obtain the reading of a single measurement in dbm, note the impedance across which the measurement is made and refer to the Impedance Correction Graph, described in paragraph 3-20.

c. To obtain the difference in dbm between measurements made across different impedances, convert each measurement to dbm using the Impedance Correction Graph described in paragraph 3-20. Then algebraically subtract the dbm levels being compared.

3-20. IMPEDANCE CORRECTION GRAPH.

3-21. As the voltmeter DECIBELS scale is calibrated to indicate dbm for measurements made across 600-ohm circuits, a correction factor must be used when measurements are made across circuit impedances other than 600 ohms, if absolute dbm levels are desired. The correction factor is not necessary in measuring relative db levels (not dbm) across the same impedance, but it is required for comparison of db levels measured across different impedances. The Impedance Correction Graph in figure 3-4 gives the correction factor for conversion of the meter reading to dbm when the impedance of the circuit under test is known. To use the graph, read the conversion factor corresponding to the test circuit impedance and add it to the meter reading determined by the method of paragraph 3-17. Observe the algebraic sign of the correction factor in making the algebraic addition. Use the following examples:

Example 1
If the measurement is made across 90 ohms, the indication on the DECIBELS scale is +2, and the RANGE switch is at the +30 DB position, the level in dbm is obtained as follows:

+ 2 (meter indication)
+30 (RANGE switch position)
+32 (sum)
+ 8 (correction factor from the Impedance
+40 dbm Correction Graph)

Example 2
For the same conditions as given above, except that the measurement is made across an impedance of 60,000 ohms, the level in dbm is obtained as follows:

+ 2 (meter indication)
+30 (RANGE switch position)
+32 (sum)
-20 (Correction factor from the Impedance
+12 dbm Correction Graph)

3-22. USE OF VOLTMETER AMPLIFIER.

3-23. The amplifier in the voltmeter may be used for amplifying weak signals. With full-scale meter deflection, the open-circuit output of the amplifier is approximately 0.15 volt rms regardless of the RANGE switch position. The impedance looking into the OUTPUT terminals is approximately 50 ohms. The frequency response and calibration of the voltmeter may be affected by the impedance of a load applied to the OUTPUT terminals. To check the effect of the applied load: observe the meter reading obtained with no load connected to the OUTPUT terminals and then note any shift of reading when the external circuit is connected to the OUTPUT terminals. If the shift is negligible, the measurement is not being affected appreciably by the load. Whenever the input signal is changed, i.e., a different frequency or band of frequencies is applied, repeat the quick check described above.

3-24. Maximum gain from the amplifier is obtainable only on the lowest (.001 volts) range, since output level is the same for all bands. This is due to the 10-db amplification loss per step inserted by the RANGE switch as it is turned clockwise. Amplification may also be obtained on the .003, .01, .03, and 1 volt ranges.

3-25. When the voltmeter is used as an amplifier, select a range which gives a meter deflection near full scale. Off-scale signals more than twice the value of the position of the RANGE switch will cause severe distortion.

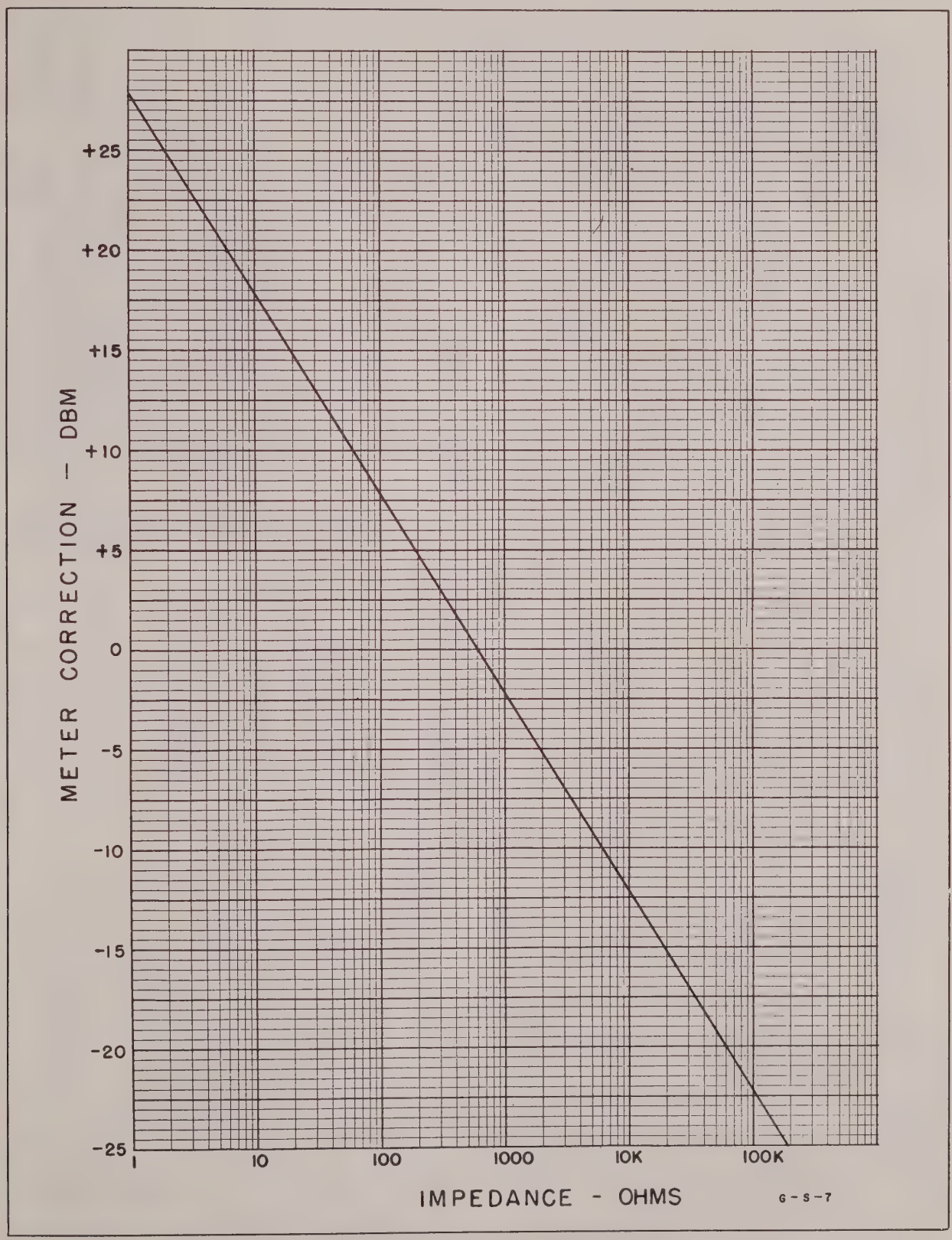


Figure 3-4. Impedance Correction Graph

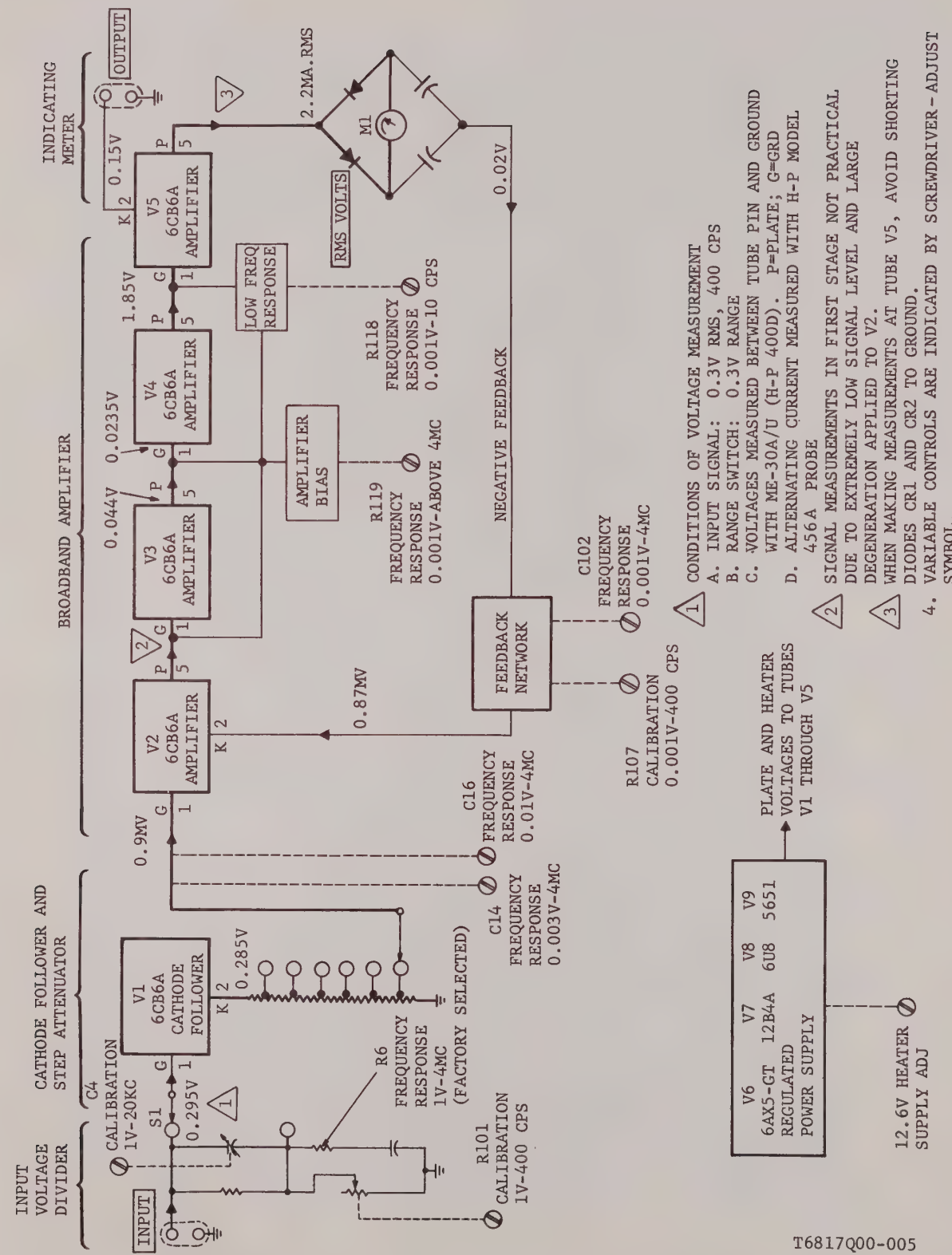


Figure 4-1. Voltmeter Block Diagram

SECTION IV

CIRCUIT DESCRIPTION

4-1. BLOCK DIAGRAM.

4-2. The electrical circuits of the voltmeter are shown in the block diagram in figure 4-1; they consist of an input voltage divider controlled by the RANGE switch, a cathode follower input tube, a precision step attenuator controlled by the RANGE switch, a broadband amplifier, an indicating meter, and a regulated power supply. The voltage applied to the INPUT terminals for measurement is divided by 1000 before application to the input cathode follower when the RANGE switch is set to the 1-volt range and higher; the input voltage is applied directly to the cathode follower on the lower ranges. The voltage from the cathode follower is divided in the precision attenuator to be less than 1 millivolt for application to the voltmeter amplifier. The output of the amplifier is rectified in a full-wave bridge rectifier with a d-c milliammeter across its midpoints. The resultant direct current through the meter is directly proportional to the input voltage.

4-3. INPUT VOLTAGE DIVIDER AND STEP ATTENUATOR.

4-4. The input voltage divider limits the signal level applied to the input cathode follower to less than 0.3 volt rms when voltages above this level are measured with the RANGE switch set at the 1-volt range or above. The divider consists of a resistive branch with one element made adjustable to obtain exact 1000:1 division at middle frequencies and a parallel capacitive branch with one element made adjustable to maintain exact 1000:1 division to beyond 4 megacycles. The input impedance of the voltmeter is established by this divider and is the same for all positions of the RANGE switch. On the six low-voltage positions of the RANGE switch, the input divider provides no attenuation of the input voltage. (See figure 5-10 for the complete schematic.)

4-5. The step attenuator in the cathode circuit of the input cathode follower reduces the voltage to be measured to 1 millivolt or less for application to the voltmeter amplifier. Each step of the attenuator lowers the signal level by exactly 10 db (1:$\sqrt{10}$). The attenuator consists of six precision wirewound resistors which are selected to very high accuracy and carefully mounted on a 12-position rotary switch. The RANGE switch rotor has two contactors (see figures 5-9 and 5-10); the first contacts each resistor in turn while the input divider is in the non-attenuating position; the second rotor finger repeats these contacts while the input attenuator is in the attenuating position. On the .003-volt range a fixed capacitor (C15) is automatically connected to provide flat frequency response beyond 4 megacycles. In the .003- and the .01-volt ranges, separate adjustable capacitors (C14, C16) are automatically connected to the attenuator to permit setting the frequency response at 4 megacycles. C14 and C16 are also connected to the attenuator on the 3- and 10-volt ranges. Fixed capacitor C106 (permanently connected) flattens frequency response on the .03- and 30-volt ranges.

4-6. Cathode follower V1 provides a constant, high input impedance to the input voltage divider and INPUT terminals of the voltmeter and provides a relatively low impedance in its cathode circuit to drive the step attenuator. The voltage gain factor across V1 is 0.95.

4-7. BROADBAND VOLTMETER AMPLIFIER.

4-8. Amplification of the signal voltage is provided by a four-stage stabilized amplifier consisting of tubes V2 through V5 and associated circuits. The amplifier provides between 55- and 60-db gain with about 55 db of negative feedback at mid-frequencies. The feedback signal is taken from the plate of the output amplifier (V5) through the meter rectifiers and gain-adjusting circuit to the cathode of the input amplifier (V2). Variable resistor R107 in the feedback network adjusts the negative feedback level to set the basic gain of the amplifier at mid-frequencies, while adjustable capacitor C102 permits setting amplifier gain at 4 megacycles. Variable resistor R118 in the coupling circuit between V4 and V5 permits adjusting the gain of the amplifier at 10 cycles per second by controlling the phase shift of low-frequency signals between these two stages (increasing phase shift decreases degeneration and increases gain).

4-9. Variable resistor R119 in the grid return path for V3, V4, and V5 adjusts the total transconductance of these tubes in order to restrict the maximum gain-bandwidth product of the amplifier. The gain-bandwidth product must be restricted to give a smooth frequency response rolloff above 4 megacycles and to prevent possible unstable operation at frequencies far above 4 megacycles when tubes having unusually high transconductance are used (tube transconductance tolerances during manufacture permit wide variations in new tubes; the adjustment permits the use of such tubes). The plate voltage from V5 is rectified by the meter rectifiers and drives the feedback network. The cathode voltage of V5 is fed to the meter OUTPUT terminals for monitoring purposes. The current through V5, and thus the signal voltage at the cathode, is affected by the loading of the meter rectifiers. For signal levels causing third-scale or more meter deflection, this distortion consists of a very small irregularity near 0 volts on the waveform as each diode begins conduction.

4-10. INDICATING METER CIRCUIT.

4-11. The meter rectifier circuit consists of two silicon diodes and two capacitors connected as a bridge with the indicating meter across the mid-points as shown in figure 4-2. The diodes provide full-wave rectification of the signal current for operating the meter. Electron flow through the meter is supplied in the following manner (see figure 4-2). During the positive-going half cycle of plate voltage on V5, rectifier CR1 conducts electrons from both C32 and C33 back to the B+ buss. The portion of electrons from C33 flows through the meter on the way to B+. At this point in the cycle, both C32 and C33 are charged to the potential of B+ less some small drop in R51 and R52.

4-12. During the negative-going half cycle of the plate voltage of V5, rectifier CR2 conducts electrons back to both C32 and C33 from the plate of V5. That portion of electrons going back to C32 flows through the meter on the way (in the same direction that the electrons flowed in the first, positive, half cycle). At this point in the cycle, both C32 and C33 are discharged. The pulsating current through the meter is smoothed by C34 to prevent meter pointer vibration when measuring low-frequency signals. The current is proportional to the arithmetic average value of the waveform amplitude of the signal. Meter calibration in rms volts is based on the mathematical ratio between the average and rms values of true sine wave current.

4-13. In addition, the bridge serves as a segment of a voltage divider (in series with L11 and R108) connected across the output of the amplifier. The negative feedback voltage fed to the input of the amplifier is obtained across L11 and R108. The alternating charge and discharge of C32 and C33 produce at their junction with L11 an alternating current of the same phase and waveform as that at the plate of V5. This phase is negative with respect to the input signal applied to the first stage of the amplifier (V2), and drives the negative feedback network.

4-14. POWER SUPPLY.

4-15. The power supply consists of tubes V6 through V9 and the associated circuits, as shown in the complete schematic diagram, figure 5-10. The power supply furnishes regulated +250V d-c voltage for the grid and plate bias circuits of tubes V1 through V5, unregulated 12.6V d-c voltage for the heater supply of tubes V1 through V4, and 6.3V a-c voltage for the heater supply of tubes V5 through V8. The power supply is designed to operate from either a 115-volt (±10%) or a 230-volt (±10%) a-c power source of 50 to 1000 cps. The primary winding of power transformer T1 is arranged in two sections, which can be strapped either in parallel or in series, to permit operation on 115V or 230V, respectively.

4-16. The output of rectifier V6 is applied to the voltage regulator circuit consisting of V7 through V9 which supplies a constant, +250 volts dc to the stabilized amplifier circuit of the voltmeter. Tube V7 is the series regulator tube, and V9 provides a fixed reference voltage drop, with which the output voltage is compared in amplifier V8B. V8A is a cathode follower which couples the reference voltage from V9 to V8B without loading V9. The regulated output voltage is applied to the control grid of V8B, while the reference voltage is applied to its cathode. The difference between the control grid and cathode voltages controls the operating point of V8B and thus its plate voltage, which in turn supplies the grid voltage for regulator V7. Any change in the regulated output of V7 produces a correcting change in the grid bias of V7 through the action of V8B, thus maintaining an essentially constant output voltage despite changes in line voltage or load on the supply. The gain of V8B is high enough to keep the output at the V7 cathode regulated

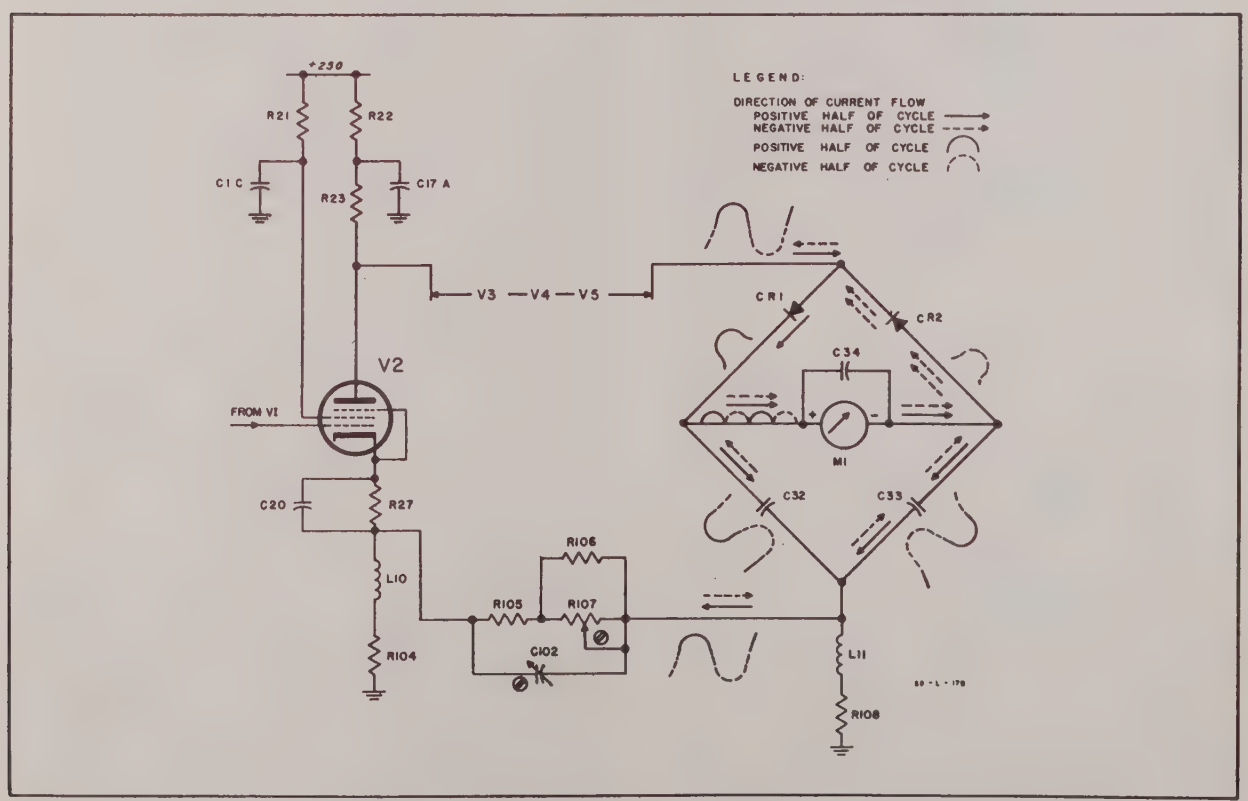


Figure 4-2. Simplified Schematic of Meter Bridge Circuit

to within ±1 volt dc as the V7 plate voltage is varied ±10%, with about 60 ma of load current. The response of the regulating circuits is fast enough to reduce ripple in the output voltage to less than 1 millivolt, supplementing the filtering action of C30. C36 couples the ripple component in the regulated output directly to V8B to avoid attenuation in R62. R57 shunts a small portion of the load current around V7 to prevent excessive V7 plate dissipation at high line voltages. R63 and C35 constitute a low-pass filter which prevents noise generated in V9 from reaching V8B.

4-17. The heater supply for the voltmeter tubes is divided into two sections. One section supplies d-c voltage for the tubes in the input cathode follower and the amplifier. The other section supplies a-c voltage for the tubes in the power supply. The voltage required for the heaters of tubes V1 through V4 is obtained from 6.3V and 7.3V secondary windings of transformer T1, which are series connected. The voltage developed across the two series-connected windings is rectified by full-wave rectifier CR3, reduced to 12.6 volts by R66 and R68 in parallel, and applied to the series-parallel-connected heaters of V1 through V4, as shown in figure 5-10. The series-parallel connection of the four heaters establishes a voltage of 6.3V for each. The heater of V5 receives 6.3V ac from one of the windings which drives CR3. The heaters of V6, V7, and V8 receive 6.3V ac from a separate 6.3V secondary winding on T1.

SECTION V
MAINTENANCE

5-1. SCOPE.

5-2. This section contains complete instructions for repairing and calibrating the voltmeter. This material is covered in the following groups of paragraphs:

Lead Paragraph	Topic
5-3.	Precautions
5-5.	Test Equipment Required
5-7.	Meter Zero Adjustment
5-9.	Cabinet Removal
5-10.	Tube Replacement
5-13.	Replacement of Special Parts
5-17.	Trouble Shooting
5-20.	Testing the Power Supply
5-22.	Testing Voltmeter Performance
5-24.	Calibration and Frequency Response Adjustments

5-3. PRECAUTIONS.

5-4. Observe the following precautions:

a. Make no adjustments and replace no parts in the voltmeter except as described in one of the following procedures. If an adjustment or replacement of parts is made without following instructions or understanding the effects, further trouble shooting may be complicated.

b. Do not remove tubes when the voltmeter is turned on. Before replacing tubes refer to paragraph 5-10.

5-5. TEST EQUIPMENT REQUIRED.

5-6. The test equipment required for complete testing of the voltmeter is listed in figure 5-1. Equivalent instruments may be substituted for those listed.

INSTRUMENT TYPE	REQUIRED CHARACTERISTICS	USE	DESIGNATION
Electronic Multimeter	0 to 300 a-c and d-c volts; accuracy of ±3% or better; input impedance 100 megohms.	Voltage and resistance measurement.	ME-26B/U or H-P 410B
Oscillator	10 cps to 300 kc; 3 volts output into 50-ohm load.	Signal source for testing and calibration.	H-P 200S
Voltmeter Calibrator (Precision Voltage Source)	400-cps output voltage; 0.001 to 300 volts in 10-db steps ±0.2%; 0.1 to 1.0 volt in 0.1 volt steps ±0.2%.	Calibrating voltmeter at mid-frequencies.	H-P 738BR
Frequency Response Test Set	300-kc to 4-mc range; 3 volts output into 50-ohm load; 10-db steps, 0 to 70 db.	Calibrating voltmeter frequency response.	H-P 739A
Oscilloscope or AC Voltmeter	10-cps to 10-mc range.	Trouble shooting by signal tracing.	AN/USM-105A, H-P 160B or H-P 400D
Variable Transformer	Adjust line voltage between 103 and 127V ac with 1-amp load.	Checking voltmeter operation with varying line voltage.	CN-16/U or Ohmite VT2
D-C Current Test Set (Milliammeter)	Clip-on type measurement; current range up to 100 ma.	Checking load on power supply.	I-206-B or H-P 428A

Figure 5-1. Test Equipment Required

5-7. METER ZERO ADJUSTMENT.

5-8. The meter is properly zero-set when its pointer rests over the zero calibration mark on the meter scale when the instrument is 1) at normal operating temperature, 2) in its normal operating position, and 3) turned off. Adjust the zero-set if necessary, as follows:

a. Allow the voltmeter to operate for 20 minutes so that the meter movement will reach normal operating temperature.

b. Turn the voltmeter off and allow one minute for all capacitors to discharge.

c. Rotate mechanical zero-adjustment screw clockwise until meter pointer is to the left of zero and moving upscale toward zero.

d. Continue to rotate adjustment screw clockwise; stop when pointer is exactly on zero. In pointer overshoots zero, repeat steps c and d.

e. When pointer is exactly on zero, rotate adjustment screw approximately 15 degrees counterclockwise. This is enough to free the zero adjustment screw from the meter suspension. If pointer moves during this step, because the adjustment screw is turned too far counterclockwise, repeat the procedure of steps c through e.

5-9. CABINET REMOVAL.

a. Remove the two cabinet retaining screws at the rear of the instrument.

b. Push the instrument chassis forward out of the cabinet. The bezel ring remains attached to the front panel.

c. When replacing cabinet, pull power cable through opening at rear of cabinet. Be sure power cable is not caught between chassis and cabinet. Replace retaining screws.

5-10. TUBE REPLACEMENT.

CAUTION

Do not remove tubes from the voltmeter when power is applied. To do so may damage the voltmeter.

5-11. In may cases instrument malfunction can be corrected by replacing a weak or defective tube. Check tubes by substitution while following the voltmeter performance check procedure in paragraph 5-22. Results obtained through the use of a "tube checker" can be misleading. Before removing the tubes from the instrument, mark the original tubes so they can be returned to the same socket if they are not defective. Replace only those tubes proven to be defective.

5-12. Figure 5-2 lists each tube in the voltmeter with its function and the check or adjustment required if the tube is replaced.

5-13. REPLACEMENT OF SPECIAL PARTS.

5-14. PRECISION RESISTORS AND INDUCTORS. Several parts used in the voltmeter have closer tolerances than those used in most test equipment. Resistors R104, R105, R108, and R111 through R116 are

CIRCUIT REF.	TYPE	FUNCTION	CHECK OR ADJUSTMENT
V1	6CB6A*	Cathode Follower	Calibration and frequency response (para. 5-22)
V2	6CB6A	1st Amplifier	
V3	6CB6A	2nd Amplifier	
V4	6CB6A	3rd Amplifier	
V5	6CB6A	4th Amplifier	
V6	6AX5	High Voltage Rectifier	Test of the power supply (para. 5-20)
V7	12B4A	Series Regulator	
V8	6U8	Control Tube	
V9	5651	Reference Tube	

*Note that V1 must be replaced by a 6CB6, aged and selected for low noise and microphonics.

Figure 5-2. Adjustments Required When Tubes Are Replaced

precision components. If these resistors require replacement, use the same value and type as the original, as shown in the parts breakdown. If different values are used or component positions are moved, the calibration of the voltmeter may be inaccurate or the frequency response may be altered. The inductance of L10 and L11 affects the frequency response of the voltmeter. Do not alter the shape or position of these coils. Install replacement components in the same positions the original components occupied, as nearly as possible.

5-15. DIODE RECTIFIERS. Special high-performance silicon diodes manufactured by the Hewlett-Packard Co. are used for CR1 and CR2. When replacing the silicon diodes, be careful in soldering; heat can damage them. Place a heat sink (such as a long-nose pliers) on each diode lead close to the diode body to conduct the heat away. If CR1 and CR2 are replaced, the voltmeter calibration and frequency response must be checked as described in paragraph 5-22.

5-16. RANGE SWITCH. Because of the critical construction and wiring of switch S1, it is not practical to attempt a major repair on the switch. When mechanical failure occurs in switch S1, replace the complete switch assembly. Use the following procedure. (Locate parts by referring to figures 5-3 and 5-4; RANGE switch connections are shown in figure 5-9.)

a. Remove voltmeter cabinet. (See paragraph 5-9.)

b. Loosen setscrews in RANGE switch knob and remove knob.

c. Disconnect capacitor C104 from switch S1.

d. Disconnect white leads from capacitors C14 and C16. Label each lead with a tag.

e. Remove the two screws and one nut which retain the switch shield plate.

f. Disconnect white leads from switch contacts. Tag each lead to permit easy connection to the new switch.

g. Disconnect the heavy dark-green switch lead, the heavy light-green switch lead, and the heavy black switch lead at terminal strips. Tag each lead.

NOTE

The input shield must be removed for access to the terminal board connection of the dark-green lead.

h. Remove the nut which holds the switch bushing to the front panel.

i. Remove RANGE switch assembly.

j. The sequence for installing the replacement RANGE switch assembly is the reverse of the removal procedure.

k. After replacement of switch S1, check the calibration and frequency response of the voltmeter and make necessary adjustments.

5-17. TROUBLE SHOOTING.

5-18. The first step in trouble shooting is to learn the nature of the symptoms of the malfunction with as much detail as possible. Inspect the test setup being used when symptoms of malfunction were observed, to be sure that the source of trouble is not external to the voltmeter. Then remove the voltmeter cabinet as directed in paragraph 5-9 and inspect the circuits of the voltmeter, looking for signs of overheating, deterioration, and physical damage or tampering. Check the fuse. If the fuse is blown, try another fuse to see if it blows; if it does, measure the d-c resistance of filter capacitors C1, C17, C30, C39, rectifier CR3, and the windings of transformer T1 to locate the short circuit without applying power to the voltmeter.

5-19. If the voltmeter can be turned on safely (without the fuse blowing), measure the line voltage applied to T1 and the voltmeter power supply output voltages (see paragraph 5-20). Check the tubes of the power supply if the regulated voltage is not the proper value or is unstable. Use the procedures of figure 5-5 and the tests described in paragraph 5-22 to learn the full nature of the trouble symptom. Watch for marginal operation by operating the voltmeter at 103 and 127 line volts while making tests. Check the tubes in the voltmeter amplifier. Measure the tube element voltages at the tube sockets and compare readings with the values shown in the voltage and resistance diagram in figure 5-8. Apply a test signal to the input and measure the voltage of the test signal while tracing it through each coupling network and each stage of amplification. Compare readings with those shown in the block diagram, figure 4-1. In figure 4-1, an a-c current probe, H-P Model 456A, is recommended for the measurement of a-c current in the meter circuit without breaking any leads. If this current probe is not available, avoid measurement of the a-c current. Check meter indications as directed in paragraph 5-22 instead. An oscilloscope may be used for observing test signal waveshape and measuring amplitude, if desired.

5-20. TESTING THE POWER SUPPLY.

5-21. The regulated power supply produces a constant +250 vdc to operate all the tubes in the amplifier section. The stability of the voltmeter depends directly upon the stability of the +250 volts from the supply. When the supply is operating satisfactorily, the +250 volt output remains constant and the ripple level on it remains less than about 1 millivolt for line voltages between 103 and 127 volts. Weak tubes (V6, V7, and V8) are the usual causes of instability.

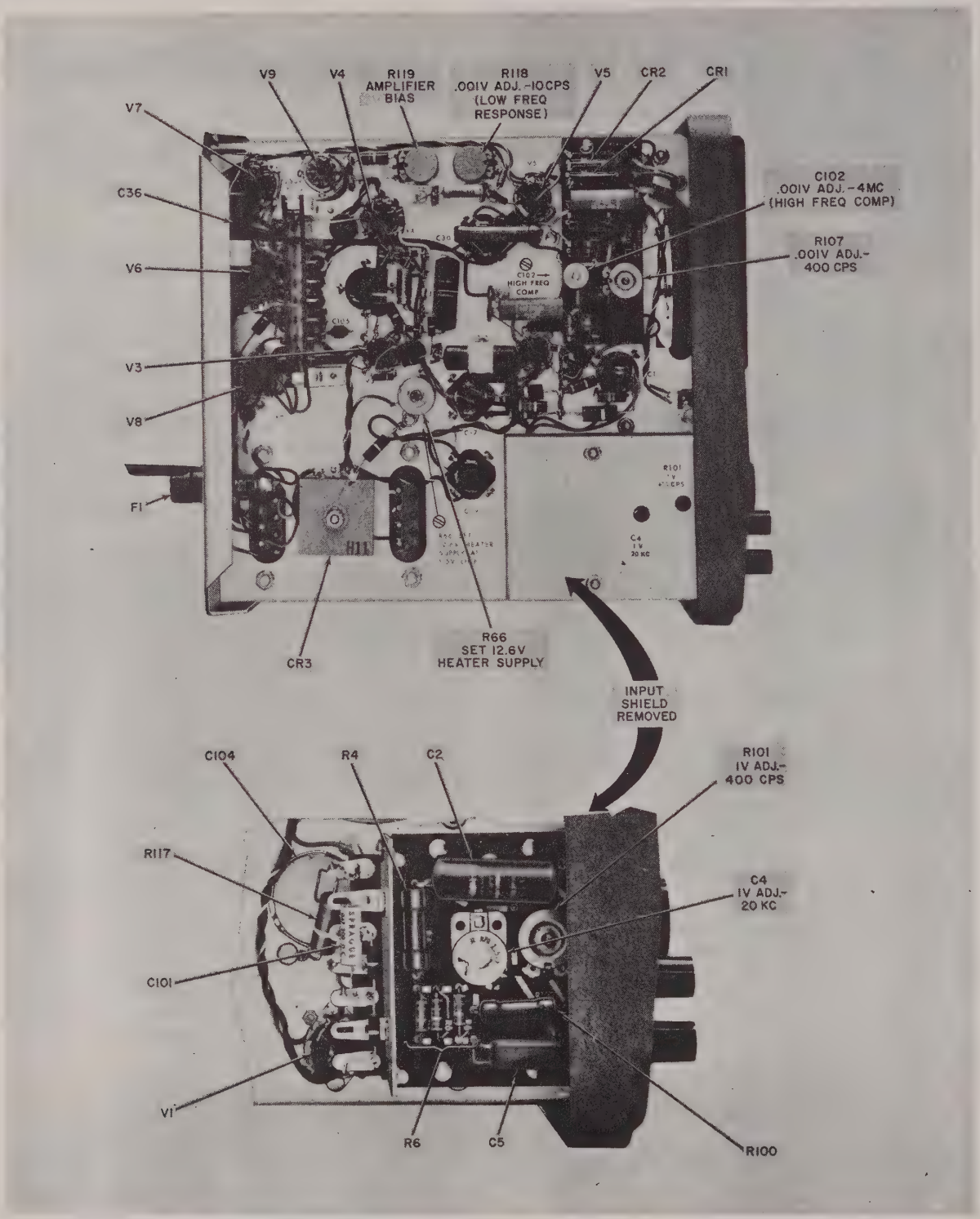


Figure 5-3. Left Side View of Voltmeter Chassis

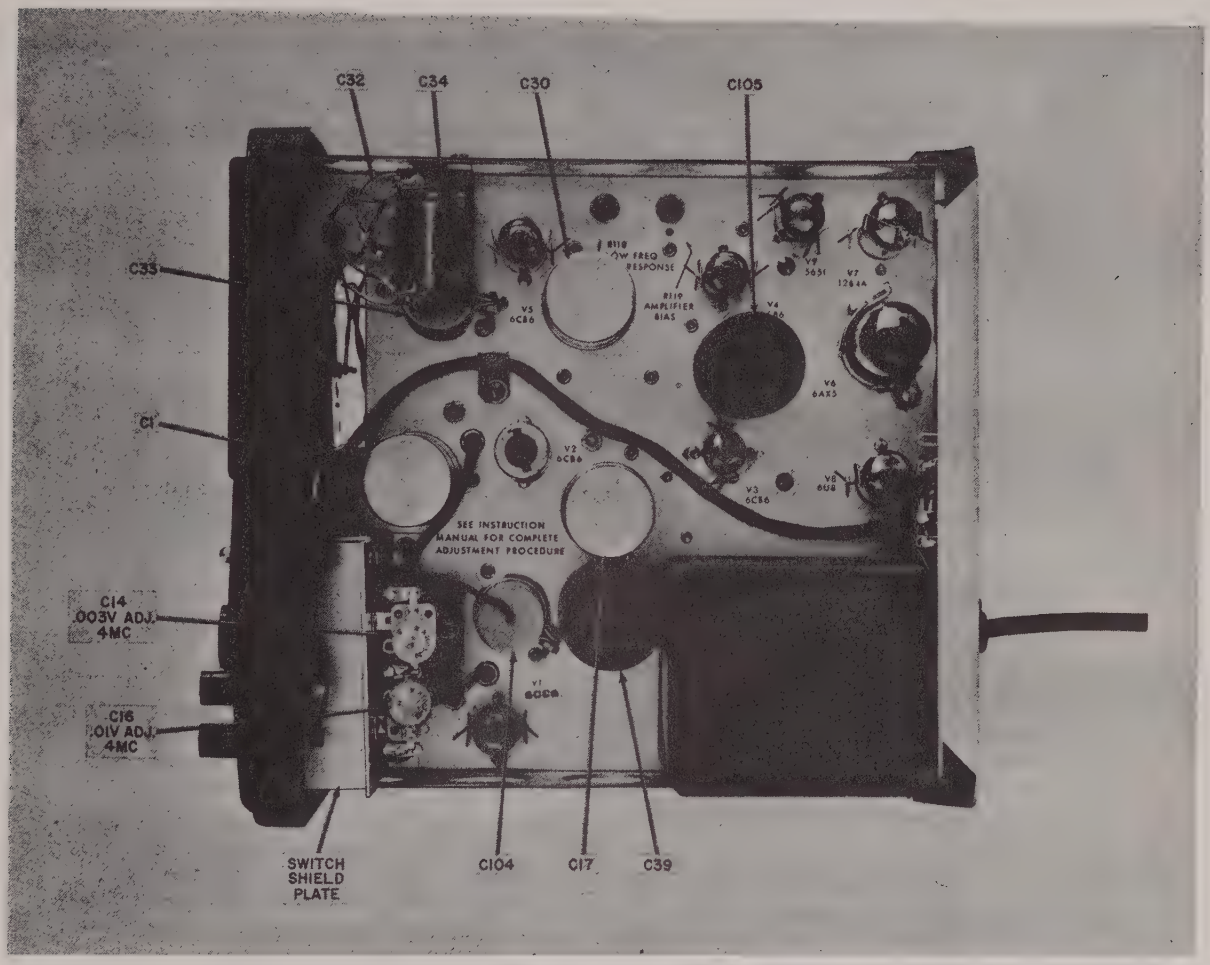


Figure 5-4. Right Side View of Voltmeter Chassis

An unstable regulator tube is indicated by excessive line frequency ripple and varying output voltage as the line voltage is changed. Marginal operation is indicated if a trouble symptom appears only when a low or high line voltage is applied. To test the complete power supply proceed as follows:

a. Connect the voltmeter to an adjustable line transformer so the applied line voltage can be varied between 103 and 127 volts. Set line voltage to 115 volts, turn on the voltmeter, and allow a five-minute warmup period.

b. Measure the d-c voltage between V6 (pin 8) and ground. Normal value is 410 (±10) volts with exactly 115-volt power line input. Lower line voltage 10% to 103 volts for 2 minutes. If the d-c voltage slowly drops below 360 volts, replace V6.

c. Measure the d-c voltage between V7 (pin 1) and ground with line voltage adjusted to 115 volts. Correct value is 250 (±5) volts.

d. Vary line voltage from 103 to 127 volts. The d-c voltage observed in step c must not change more than ±1 volt. For wrong voltage and/or poor regulation, replace V7, V8, or V9.

e. Measure the a-c voltage between V7 (pin 1) and ground. Ripple voltage must be less than 3 mv for any line voltage (103 to 127 volts). High ripple voltage is caused by defective V8, V7, V6, or V9. Replace in this order.

f. Measure the direct current in the lead from V7 (pin 1) which must be less than 60 milliamperes. If the current is much too high, the regulator circuit will not function properly. Excessive current indicates a short circuit or partial short in the circuits of the voltmeter amplifier section. A clip-on type milliammeter should be used for this measurement.

g. If the output voltage is stable but is incorrect, measure the resistance of R62 and R64. The ratio of

TROUBLE	PROBABLE CAUSE	REMEDY
1. Power indicator lamp does not light.		
	a. Fuse F1 burned out.	a. Replace fuse F1. If replaced fuse blows, check items 2 and 3 below.
	b. Power indicator lamp DS1 defective.	b. Replace power indicator lamp DS1.
	c. Defective a-c power cable.	c. Repair or replace power cable.
	d. Power switch S2 defective.	d. Replace Power switch S2.
	e. Transformer T1 primary winding terminals incorrectly connected.	e. Check connections of transformer T1 primary winding; rewire if necessary.
2. Fuse F1 blows immediately when Power switch S2 is operated to ON.		
	a. Tube V6 shorted.	a. Replace rectifier tube V6.
	b. Rectifier CR3 defective.	b. Replace heater rectifier CR3.
	c. Short circuit in transformer T1 or in circuit wiring.	c. Remove all tubes, and check transformer windings. Replace transformer T1 if defective. Check for short circuit.
3. Fuse F1 blows after Power switch S2 has been operated to ON and tube heaters have warmed up.		
	Short in power supply circuit.	Check for short circuit at cathodes V6 and V7. Replace defective component.
4. Power indicator lamp lights; voltmeter does not indicate on all ranges.		
	a. Power supply or voltage regulator circuits defective.	a. Check tubes V6, V9, V7, and V8 in turn. Check high-voltage winding of transformer T1. Replace defective component.
	b. Rectifier CR3 or circuit component defective.	b. Check for 12.6 volts dc across output of rectifier CR3. Check resistors R66 and R68. If tubes V1 and V2 are not lighted, check capacitor C39. Replace defective component.
	c. Diode CR1 or CR2 defective.	c. Replace diode (paragraph 5-15).
5. Meter indication normal on low ranges (.001 to .3 volts). Meter sensitivity distorted on high-voltage ranges (1 to 300 volts).		
	Compensated 1000:1 divider defective.	Check C4 and R4. Replace defective component.
6. Meter indicates low on all ranges.		a. Check B+ voltage (paragraph 5-20). Check tubes V2 through V5 for low emission. If any tube is replaced, check and recalibrate the voltmeter (paragraph 5-22).
	a. Low amplifier gain.	
	b. Diode CR1 or CR2 defective.	b. Replace diode (paragraph 5-15).
7. Meter indication unstable or erratic.		
	a. Power supply, circuit defective.	a. Check heaters and B+ voltage. Replace defective component.
	b. Amplifier tube V1, V2, V3, V4, and V5 defective.	b. Check V1 through V5 for microphonics or noise. If tube is replaced, check and recalibrate the voltmeter (paragraph 5-22).
8. Meter indication normal on .001 and 1 volt range. Meter sensitivity distorted on all other ranges (.003, .01, .03, .1, .3, 3, 10, 30, 100, and 300 volts).		
	Faulty RANGE switch S1.	Check switch contacts of S1. Replace RANGE switch S1 if defective (paragraph 5-16).

Figure 5-5. Trouble Shooting Procedure

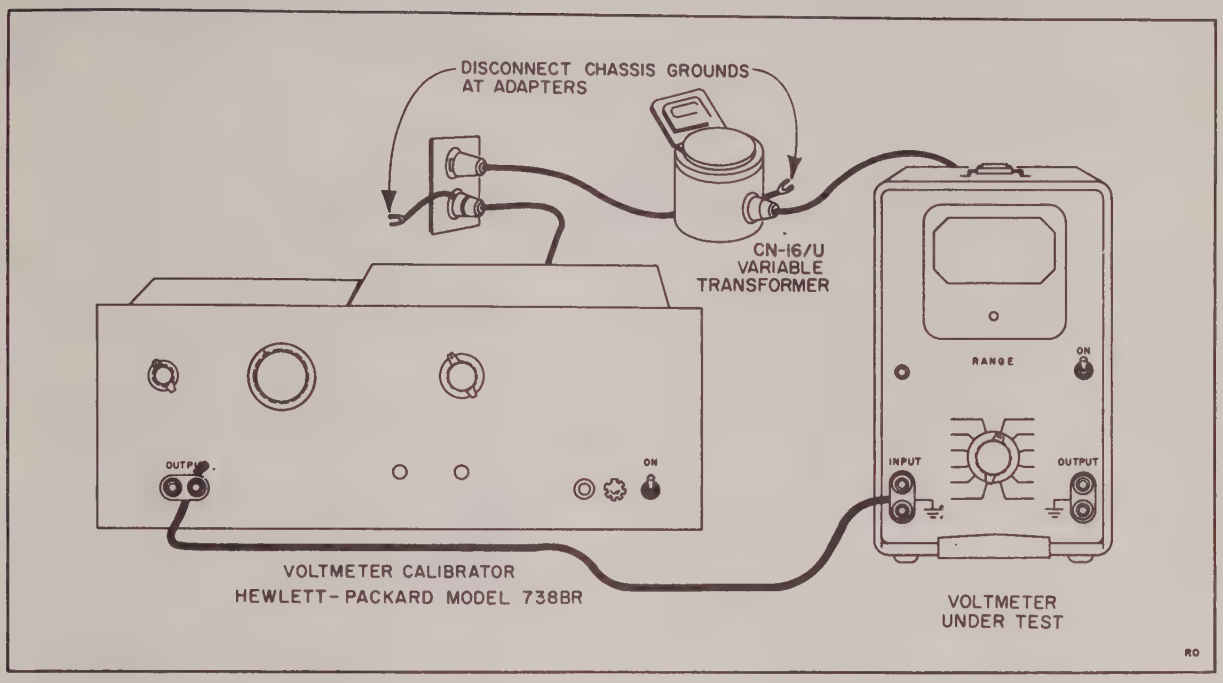


Figure 5-6. Test Setup for Calibration Check and Adjustments

these two resistors determines what the output voltage will be. If the value of one of these resistors is incorrect and produces the wrong output voltage, replace it with a resistor which provides the correct output voltage.

h. Measure the d-c voltage across C39A which must be 12.6 volts with a line voltage of 115 volts. If necessary, adjust R66 to obtain 12.6 volts. If the voltage cannot be set to 12.6 volts, check the a-c voltage from the associated transformer windings; also check CR3 and C39.

5-22. TESTING VOLTMETER PERFORMANCE.

5-23. The following test procedure checks the accuracy and stability of the voltmeter at low and high frequencies and with low and high line voltages. It can be used for comprehensive incoming inspection, for proof of performance, and for trouble shooting. If the readings are within specifications during these tests, the voltmeter is operating properly. This test is made without removing the cabinet. Instruments used to test the accuracy of the voltmeter (see paragraph 5-5) must be known to have sufficient accuracy to make valid measurements. Proceed as follows:

a. Connect the voltmeter as shown in figure 5-6. (This setup measures calibration accuracy at mid-frequencies.)

b. Set the line voltage to 115 volts, turn the voltmeter on and allow a 30-minute warmup period.

c. Check the instrument meter zero setting as instructed in paragraph 5-7.

d. Connect the voltmeter to the voltmeter calibrator; set voltmeter RANGE switch to .001, and set voltmeter calibrator VOLTAGE SELECTOR switch to provide zero volts output. The residual reading on voltmeter must be no higher than the residual reading obtained with voltmeter INPUT terminated with a 10-megohm resistor and shielded to prevent stray pickup. If the residual reading is higher when connected to the calibrator, refer to paragraph 3-12.

e. Set the voltmeter RANGE switch to .001. Set the voltmeter calibrator to provide 0.001 volt rms (400 cps) output. Record deviation of voltmeter reading from 1 on the voltmeter scale.

f. Set the voltmeter RANGE switch to 1. Set the voltmeter calibrator to provide 1 volt rms output. Record deviation of voltmeter reading from 1 on the voltmeter scale.

g. Still using the voltmeter 1-volt range, reduce the voltmeter calibrator output in 0.1 volt steps. Record deviation of voltmeter readings from each 0.1 volt calibration mark.

h. Compare recorded deviations with the permissible errors listed in the performance specifications in figure 1-2.

i. Connect the voltmeter as shown in figure 5-7 and set line voltage to 115. (This setup measures calibration accuracy at low and high frequencies.)

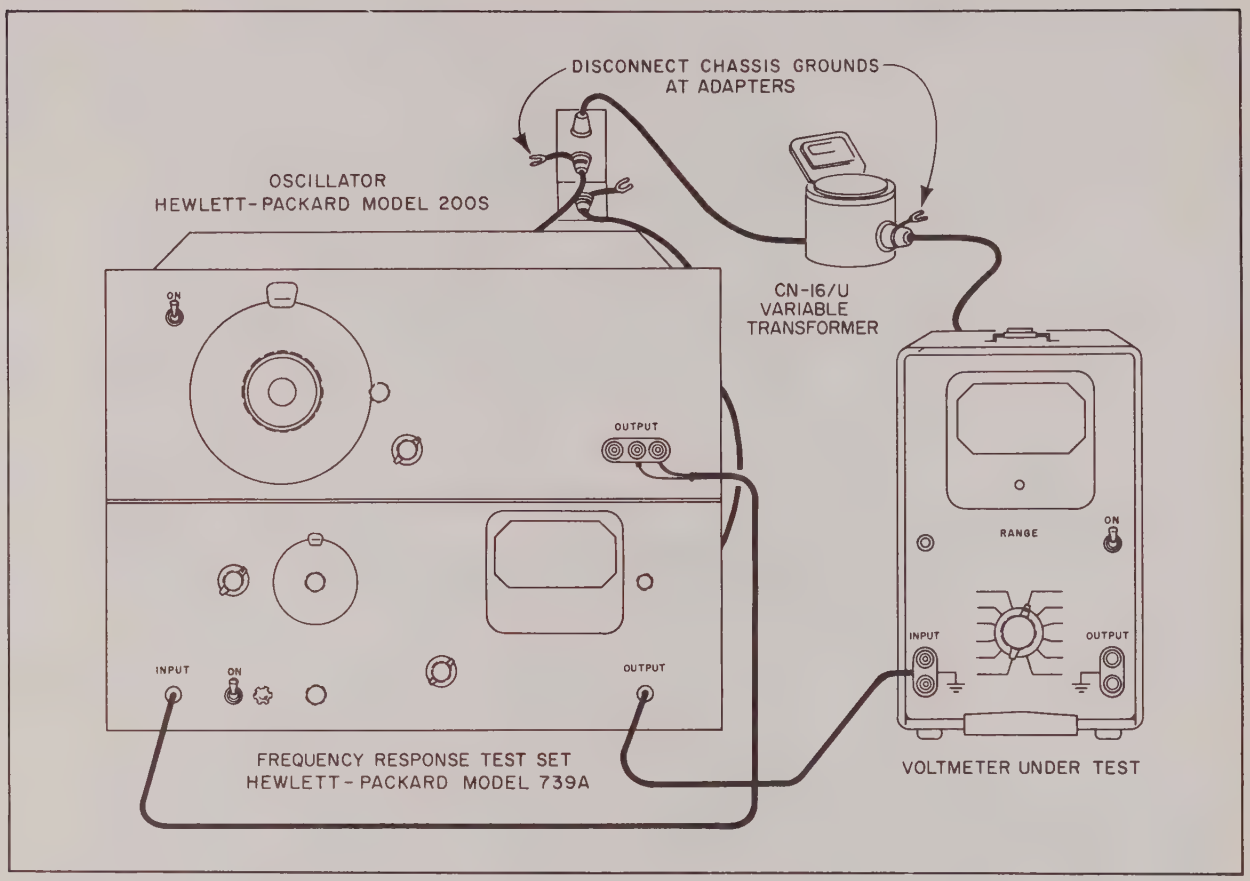


Figure 5-7. Test Setup for Frequency Check and Adjustment

j. Set voltmeter RANGE switch to .001. Set frequency response test set OUTPUT ATTENUATOR to .001 to measure the lowest voltmeter range; initially set AMPLITUDE control for 0 volts output. Then note voltmeter reading; it must not be higher than the residual reading noted in step d.

k. Turn the frequency response test set RANGE SELECTOR to EXTERNAL. Set the external oscillator frequency to 400 cps; adjust the oscillator output level to obtain a reading of .9 on the 0 to 1 VOLTS scale of the voltmeter. Then adjust the METER SET control on the frequency response test set to obtain a standard meter indication at the SET LEVEL mark on the test set meter.

l. Tune the external oscillator to 10 cps and adjust its output level to keep the frequency response test set meter reading at SET LEVEL. Do not adjust the METER SET control as this would alter the fixed monitoring point of the meter. Record the voltmeter deviation from .9 on the scale. This reading must be between 0.85 and 0.95 to be within specifications.

m. Set the RANGE SELECTOR on the test set to 3-10 mc, set the FREQ. TUNING dial to 4, and adjust the AMPLITUDE control to keep the frequency response test set meter reading at SET LEVEL. Record the voltmeter deviation from .9 on the scale. This reading must be between 0.85 and 0.95 to be within specifications. The gain and frequency response of the basic voltmeter amplifier is now tested.

n. Repeat step m using line voltages of 103 and 127. Record voltmeter deviation from .9 on the scale.

o. Set voltmeter RANGE switch to .003 and also set the frequency response test set OUTPUT ATTENUATOR to .003 to check this voltmeter range. Repeat steps k and m. Record voltmeter deviation from .9 on the scale.

p. Set voltmeter RANGE switch to .01 and also set the frequency response test set OUTPUT ATTENUATOR to .01 to check this voltmeter range. Repeat steps k and m. Record voltmeter deviation from .9 on the scale.

q. Set voltmeter RANGE switch to 1 and also set the frequency response test set OUTPUT ATTENUATOR to 1. Repeat step k.

r. Turn the frequency response test set RANGE SELECTOR to EXTERNAL. Set external oscillator

frequency to 20 kc and adjust output level to keep the frequency response test set meter reading at SET LEVEL. Record voltmeter deviation from .9 on the scale.

s. Repeat step m and record voltmeter deviation from .9 on the scale.

t. The voltmeter is now completely tested. If the measurements made have shown the voltmeter reading to be within the tolerances given in the performance specifications in Section I, the voltmeter is operating satisfactorily. If operation is unsatisfactory, make calibration and frequency reponse adjustments as directed in paragraph 5-24.

5-24. CALIBRATION AND FREQUENCY RESPONSE ADJUSTMENTS.

5-25. Calibration shall be performed in accordance with T.O. 33K1-4-1, Section 22. Should the voltmeter not meet the calibration requirements, locate and replace the defective components and perform the voltmeter performance tests outlined in paragraph 5-22 to see if adjustments are necessary. If the voltmeter operates within specifications during the test of paragraph 5-22, with respect to both calibration (at midfrequencies) and frequency response, no adjustments are needed. If operation at midfrequencies meets calibration specifications, only the frequency response adjustments need be made. Otherwise, make all calibration and frequency response adjustments in the order listed in the following procedure.

5-26. Alignment of the voltmeter consists of five parts:

a. Setting the basic gain of the amplifier at 400 cps.

b. Setting the division ratio of the input attenuator at 400 cps.

c. Setting the frequency response of the amplifier.

d. Setting the 4-mc frequency response of the step attenuator.

e. Setting the 20-kc and 4-mc frequency response of the input divider.

NOTE

It is important to follow the complete procedure in the order given, instead of attempting individual adjustments which might appear to correct a certain fault in calibration.

5-27. Although a special voltmeter calibrator instrument and frequency response test set (listed in paragraph 5-5) are shown for calibrating the voltmeter, other precision a-c voltage sources having the required accuracy may be used for this calibration procedure. In the following procedure, the mechanical meter zero-set and the regulated B+ voltage must already be correctly set (see paragraphs 5-7 and 5-20, respectively). Proceed as follows:

a. Connect voltmeter calibrator and voltmeter under test as shown in figure 5-6. (Do not turn on.)

b. Provide a ground-level input to the voltmeter to check for stray pickup between the instruments by setting the voltmeter calibrator controls as follows:

OUTPUT SELECTOR to 400 ~ RMS
RANGE SELECTOR switch to 1.5-5
VOLTAGE SELECTOR switch to 0
POWER switch to ON

c. Set the RANGE switch on the voltmeter under test to .001 volt, and the Power switch to ON. Allow at least a ten-minute warmup. Refer to paragraph 3-12 of this manual and to the manual for the Model 738BR Voltmeter Calibrator for a procedure to test for ground currents. Eliminate any ground currents by breaking ground loops as directed in paragraph 3-12.

d. To test the .001 volt range, set the voltmeter calibrator switch to .001 and the voltmeter RANGE switch to .001. If necessary, adjust R107 (figure 5-3) to obtain a reading of exactly 1 on the 0 to 1 VOLTS scale on the panel meter of the voltmeter under test. This sets the gain of the amplifier at audio frequencies.

e. Set the RANGE switch on the voltmeter to the 1-volt range. Set the voltmeter calibrator switch to 1 to test this range. If necessary, adjust R101 (figure 5-3) to obtain a reading of exactly 1 volt on the voltmeter. This sets the division ratio of the input voltage divider at audio frequencies.

f. Connect the frequency response test set, the oscillator, and the voltmeter under test as shown in figure 5-7. Observe grounding precautions described in step c.

g. On the frequency response test set, set the OUTPUT ATTENUATOR to .001, the RANGE SELECTOR to EXTERNAL, and turn the Power switch ON. This adjusts the frequency response test set to provide an output from the external oscillator for the voltmeter .001-volt range.

h. Set the RANGE switch on the voltmeter under test to .001.

i. Set the oscillator for 400 cps output frequency and adjust its output level to obtain a reading at 0.9 on the voltmeter scale.

j. Adjust the frequency response test set METER SET control to obtain a meter reading at SET LEVEL on the test set. This standardizes the monitoring point of the output level.

k. Set the RANGE SELECTOR and FREQ. TUNING controls of the frequency response test set for 4-mc output frequency and adjust the AMPLITUDE control to provide a reading at SET LEVEL on the meter.

l. If necessary adjust C102 (figure 5-3) to obtain a reading at 0.9 on the voltmeter under test. This sets amplifier gain at video frequencies.

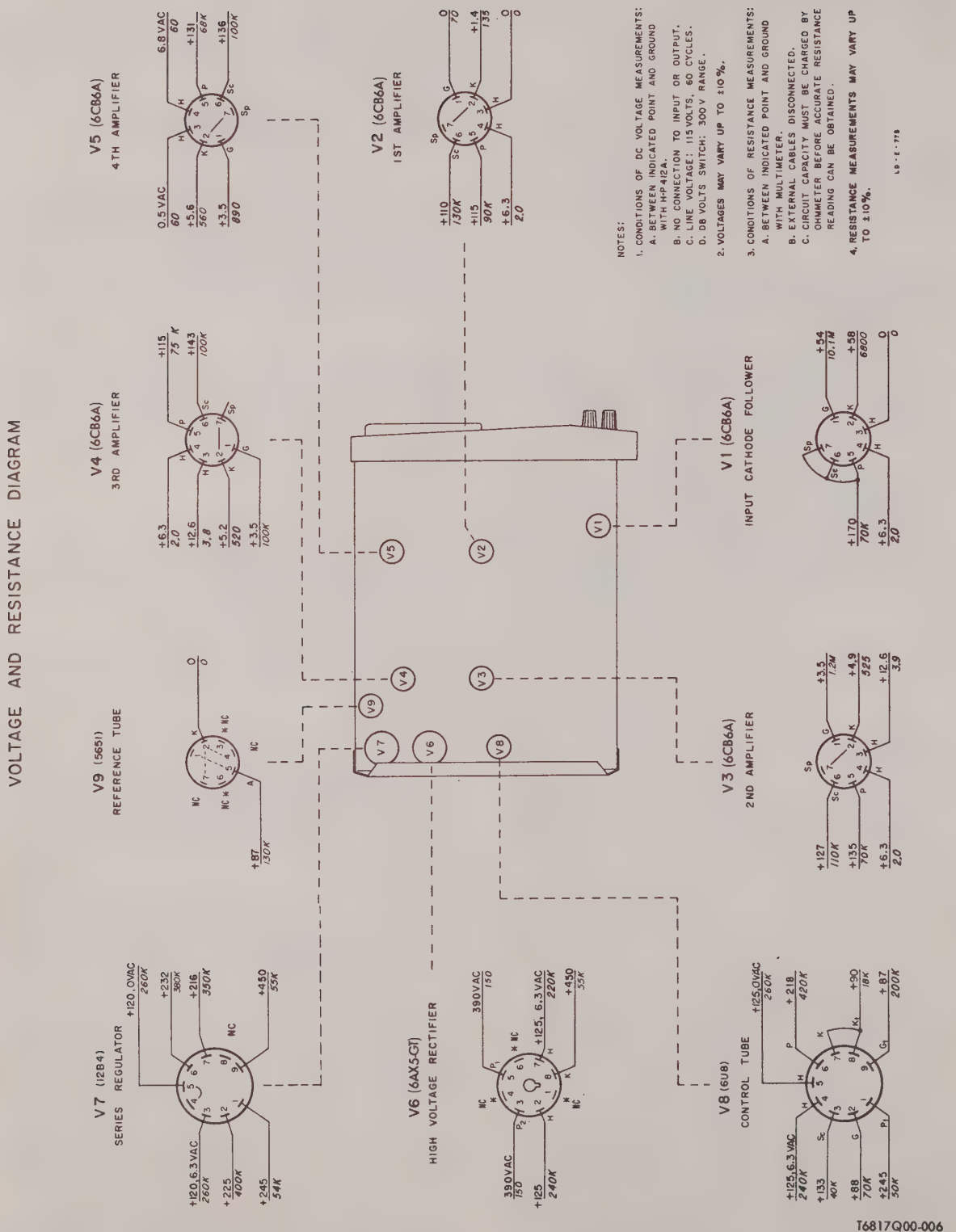


Figure 5-8. Voltage and Resistance Diagram

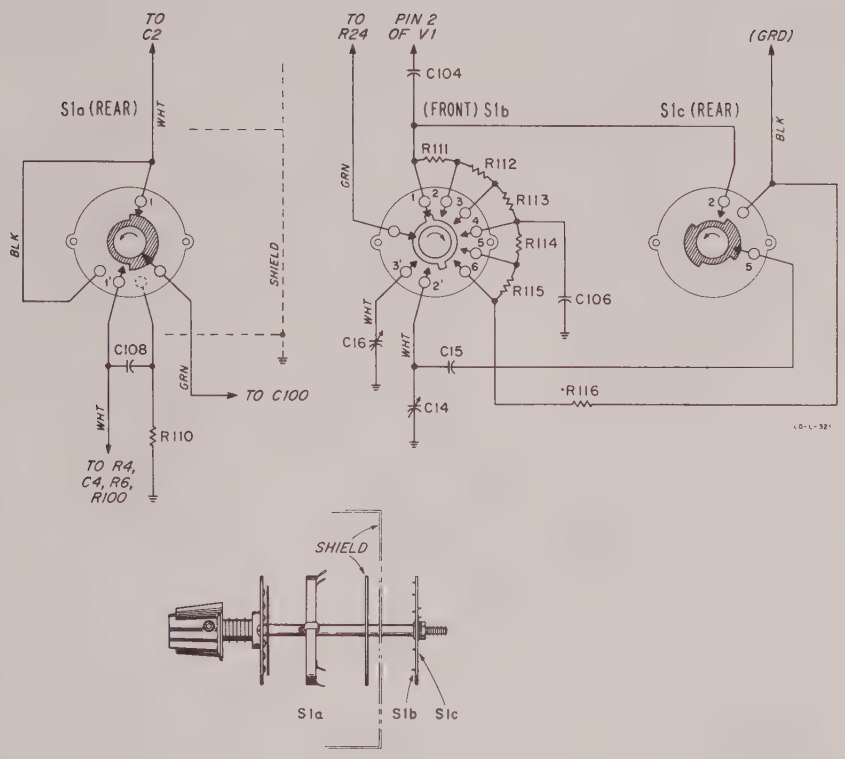


Figure 5-9. Diagram of RANGE Switch

m. While watching voltmeter under test, adjust the frequency response test set FREQ. TUNING control from 4 to 10 megacycles while holding output level constant with the AMPLITUDE control. If voltmeter reading increases beyond 0.92 on the scale (+2%), adjust R119 to limit this peak to 0.92 and repeat steps g through l.

NOTE

Whenever R119 is adjusted, both the low- and high-frequency response is affected and must be retested.

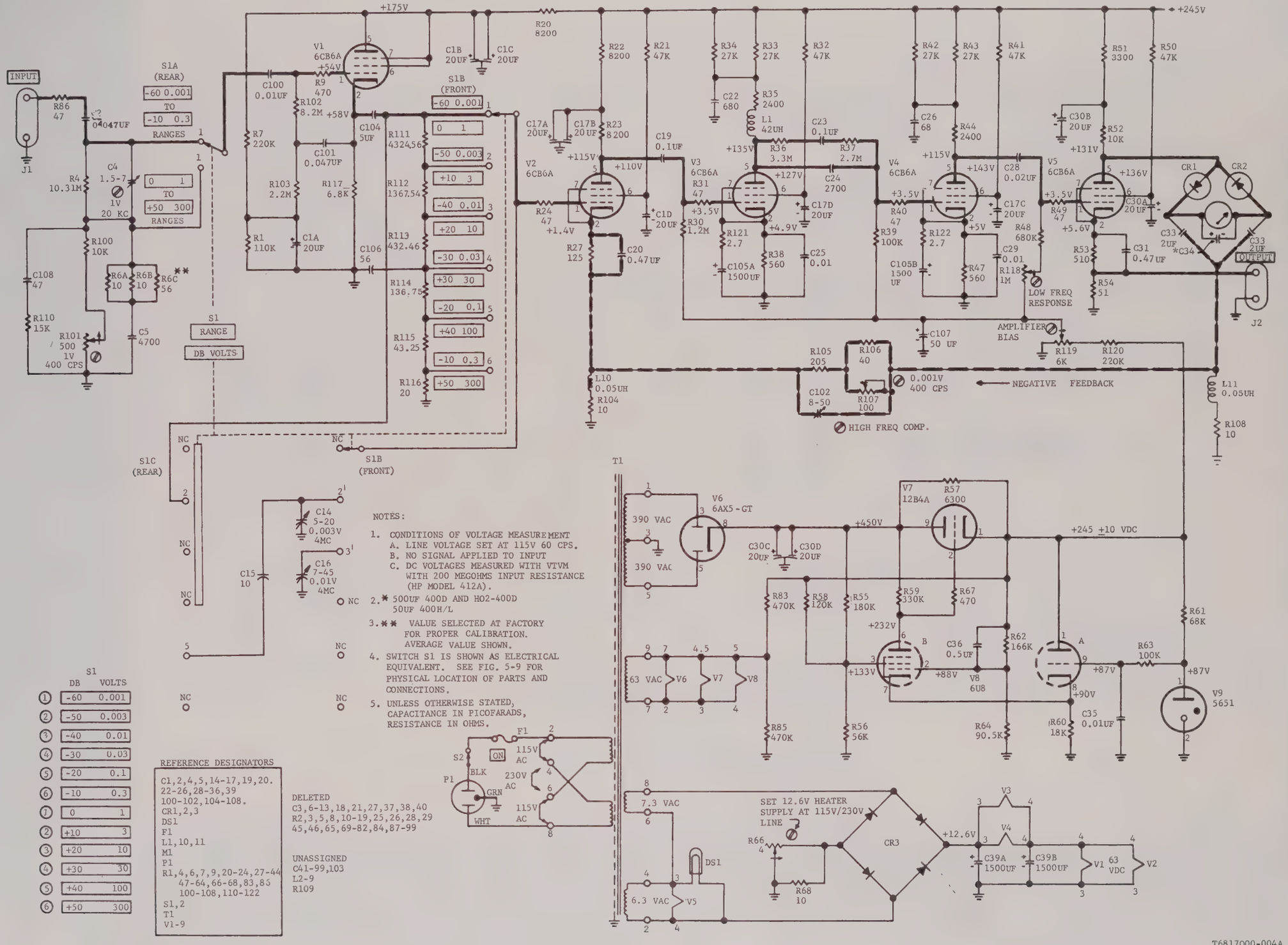
n. Readjust oscillator and frequency response test set for 20 cps output and a SET LEVEL indication on the test set meter. If necessary adjust R118 (figure 5-4) to obtain a reading at exactly 0.9 on the voltmeter under test.

o. Repeat step n at a frequency of 10 cps, for a voltmeter reading between 0.85 and 0.95 (±5%). If 10 cps response is outside this range, readjust R118 slightly to bring 10 cps response within the specified limits.

p. Repeat the 400-cps to 4-mc frequency response check (steps g through k) on the .003 volt range of the voltmeter and if necessary adjust C14 (figure 5-4) to obtain a reading of 0.9 on the voltmeter at 4 mc.

q. Repeat the 400-cps to 4-mc frequency response check (steps g through k) on the 0.01 volt range of the voltmeter and if necessary adjust C16 (figure 5-4) to obtain a reading of 0.9 on the voltmeter at 4 mc.

r. On the 1-volt range of the voltmeter, measure frequency response at both 20 kc and 4 mc using a procedure similar to steps g through k. At 20 kc if necessary adjust C4 (figure 5-3) to obtain a reading of 0.9 on the voltmeter. At 4 mc if necessary pad the value of R6 (figure 5-3) to obtain a reading between 0.85 and 0.95 (±5%). R6 consists of several resistors connected in parallel. Increasing the value of one of these resistors raises the meter reading at 4 mc. The input shield must be in place on the voltmeter chassis when making this reading.



NOTES:

1. CONDITIONS OF VOLTAGE MEASUREMENT
   A. LINE VOLTAGE SET AT 115V 60 CPS.
   B. NO SIGNAL APPLIED TO INPUT
   C. DC VOLTAGES MEASURED WITH VTVM WITH 200 MEGOHMS INPUT RESISTANCE (HP MODEL 412A).
2. * 500UF 400D AND HO2-400D 50UF 400H/L
3. ** VALUE SELECTED AT FACTORY FOR PROPER CALIBRATION. AVERAGE VALUE SHOWN.
4. SWITCH S1 IS SHOWN AS ELECTRICAL EQUIVALENT. SEE FIG. 5-9 FOR PHYSICAL LOCATION OF PARTS AND CONNECTIONS.
5. UNLESS OTHERWISE STATED, CAPACITANCE IN PICOFARADS, RESISTANCE IN OHMS.

S1

	DB	VOLTS
1	-60	0.001
2	-50	0.003
3	-40	0.01
4	-30	0.03
5	-20	0.1
6	-10	0.3
1	0	1
2	+10	3
3	+20	10
4	+30	30
5	+40	100
6	+50	300

REFERENCE DESIGNATORS

C1,2,4,5,14-17,19,20. 22-26,28-36,39 100-102,104-108.
CR1,2,3
DS1
F1
L1,10,11
M1
P1
R1,4,6,7,9,20-24,27-44 47-64,66-68,83,85 100-108,110-122
S1,2
T1
V1-9

DELETED
C3,6-13,18,21,27,37,38,40
R2,3,5,8,10-19,25,26,28,29 45,46,65,69-82,84,87-99

UNASSIGNED
C41-99,103
L2-9
R109

T6817Q00-004A

Figure 5-10. Voltmeter Schematic Diagram

SECTION VI

INTRODUCTION TO ILLUSTRATED PARTS BREAKDOWN

6-1. GENERAL.

6-2. This Illustrated Parts Breakdown lists and describes the parts applicable to the Vacuum Tube Voltmeters, Models 400D, 400DR, 400H, 400HR, 400L, 400LR and H02-400D, manufactured by Hewlett-Packard Co., Loveland, Colorado, U.S.A. The breakdown consists of four sections as shown in the Table of Contents.

6-3. GROUP ASSEMBLY PARTS LIST. The Group Assembly Parts List (Section VII) consists of the complete Voltmeter divided into six main assemblies or components as shown in the Table of Contents. Each assembly listed is followed immediately by its component parts indented to show relationship to the assembly.

6-4. Part numbers are used to identify parts. A MIL-type part number or a typical manufacturer and part number are listed for each vendor part in the Group Assembly Parts List.

6-5. The index numbers are numerically arranged in the Group Assembly Parts List and are used mainly to assist in locating a part in the Group Assembly Parts List after it has been found in the Numerical Indexes (Section VIII) or located on the figure which illustrates that particular assembly.

6-6. The nomenclature of each part in the Group Assembly Parts List is indented to indicate assembly relationship. Each part is indented one column to the right of the next higher assembly. When the details of an assembly are shown on a different figure and parts list, the nomenclature of that assembly is followed by a parenthetical note stating in which figure and parts list the details will be found.

6-7. Attaching parts are shown in the same indent as the parts which they attach, and immediately following the part. They are separated from the parts which they attach by the words (ATTACHING PARTS). The attaching parts are separated from the following assembly, or the details of the assembly which they attach, by the symbol ---*---. When attaching parts are shown as attaching two or more parts, the quantities of the attaching parts are those required to attach the total number of the assemblies or parts being attached.

6-8. The quantities listed in the "Units per Assy" column of the Group Assembly Parts List are, in the case of assemblies, the total quantity used in the Voltmeter at the location indicated. In the case of component parts indented under the assembly, the quantity listed is the quantity used per assembly. The quantities specified in any one entry, therefore, are not necessarily the total used per complete Voltmeter. Refer to the Numerical Index (Section VIII) for the total quantities used per complete voltmeter.

6-9. USABLE ON CODE. Part variations within the voltmeters are indicated by a letter symbol or combination of letter symbols in parentheses immediately following the figure and index number in the same column. An explanation of the symbols used is outlined below. In cases where the "Usable on Code" column has been left blank, parts listed apply to all models covered by this book.

USABLE ON CODE	MODEL NUMBER
D	400D
DR	400DR
H	400H
HR	400HR
L	400L
LR	400LR
H02	H02-400D

6-10. NUMERICAL INDEX. The Numerical Index (Section VIII) is compiled in accordance with the numerical part number filing system described below:

a. Part number numerical arrangement starts at the left-hand position of the part number and continues from left to right, one position at a time, until part number numerical arrangement is determined for all the part numbers.

b. The order of precedence in the arrangement of the part number is as follows:

(1) Space (blank position in the number)

(2) Dash (-)

(3) Letters A through Z

(4) Numerals 0 through 9
Alphabetical O's shall be considered as numerical zeros

6-11. In cases where the same part appears in several assemblies and therefore has several different figure and/or index numbers, the Numerical Index lists the figure and index number of each appearance, and the total quantity of the part used is given on the line with the first figure and index number entry.

6-12. REFERENCE DESIGNATION INDEX. The Reference Designation Index (Section IX) lists electrical parts by reference designator and is compiled with reference designators in alpha-numerical order. It provides a convenient method for locating parts within the Group Assembly Parts List when the reference designator is known.

6-13. SOURCE CODING. Source coding as applied to the Numerical Indexes has been assigned by Department representatives.

SOURCE CODE DEFINITIONS

a. CODE "P" - PARTS UNDER INVENTORY STOCK CONTROL

(1) CODE "P" is applied to the parts which are procured in view of relatively high usage. Code "P" parts may be requisitioned and installed by any maintenance level, unless followed by the letter - "O", which restricts requisition and replacement to Depot (O&R) level only. Restricted service manufacture is considered practicable but only after an attempt has been made to procure from Supply Sources. In lieu of the procurement of "P" coded parts, the Department may designate a Depot (O&R) level activity to manufacture supply requirements for the Program.

(2) CODE "P1" is applied to parts which are very difficult or uneconomical to manufacture. Service manufacture is considered impracticable. Code "P1" parts may be requisitioned and installed by any maintenance level, unless followed by the letter - "O" which restricts the requisition and replacement to Depot (O&R) level only.

b. CODE "M" MANUFACTURE, PARTS NOT PROCURED

(1) CODE "M" is applied to parts which are within the facilities of any activity to manufacture. Procurement and stocking are not justified in view of the relatively low usage, or storage and installation factors, of these parts. Needs are to be met by local manufacture as required.

(2) CODE "M1" is applied to parts which can be manufactured only by utilizing the facilities of the Depot (O&R) activity. Procurement and stocking of these parts are not justified in view of their relatively low usage and installation factors. The needs of all activities are to be met through salvage, or by Depot (O&R) level manufacture.

c. CODE "A" ASSEMBLE - ASSEMBLY NOT PROCURED

(1) CODE "A" is applied to assemblies made up of two or more units each of which carry individual part numbers and descriptions, and which may be assembled by any maintenance level.

(2) CODE "A1" is applied to assemblies made up of two or more parts each of which carry individual part numbers and descriptions, and which may be assembled only by activities having Depot (O&R) facilities.

d. CODE "X" PARTS CONSIDERED IMPRACTICABLE FOR MANUFACTURE OR PROCUREMENT

(1) CODE "X" is applied to parts which, if required, would suggest extensive equipment reconditioning. The need of a part, or parts, coded "X" should normally result in a recommendation to retire the equipment from service.

(2) CODE "X1" is applied to parts for which the procurement of the next larger assembly is justified; e.g., an integral detail part, inseparable from its assembly; a part machined in a matched set; or a part of an assembly which, if required, would suggest extensive reconditioning of each assembly.

(3) CODE "X2" is applied to parts which are neither procured nor stocked. Activities requiring such parts shall attempt to obtain from salvage; if not obtainable from salvage, such parts shall be requisitioned through normal supply channels with supporting justification.

e. CODE * PARTS NOT PROCURED, MANUFACTURED OR STOCKED

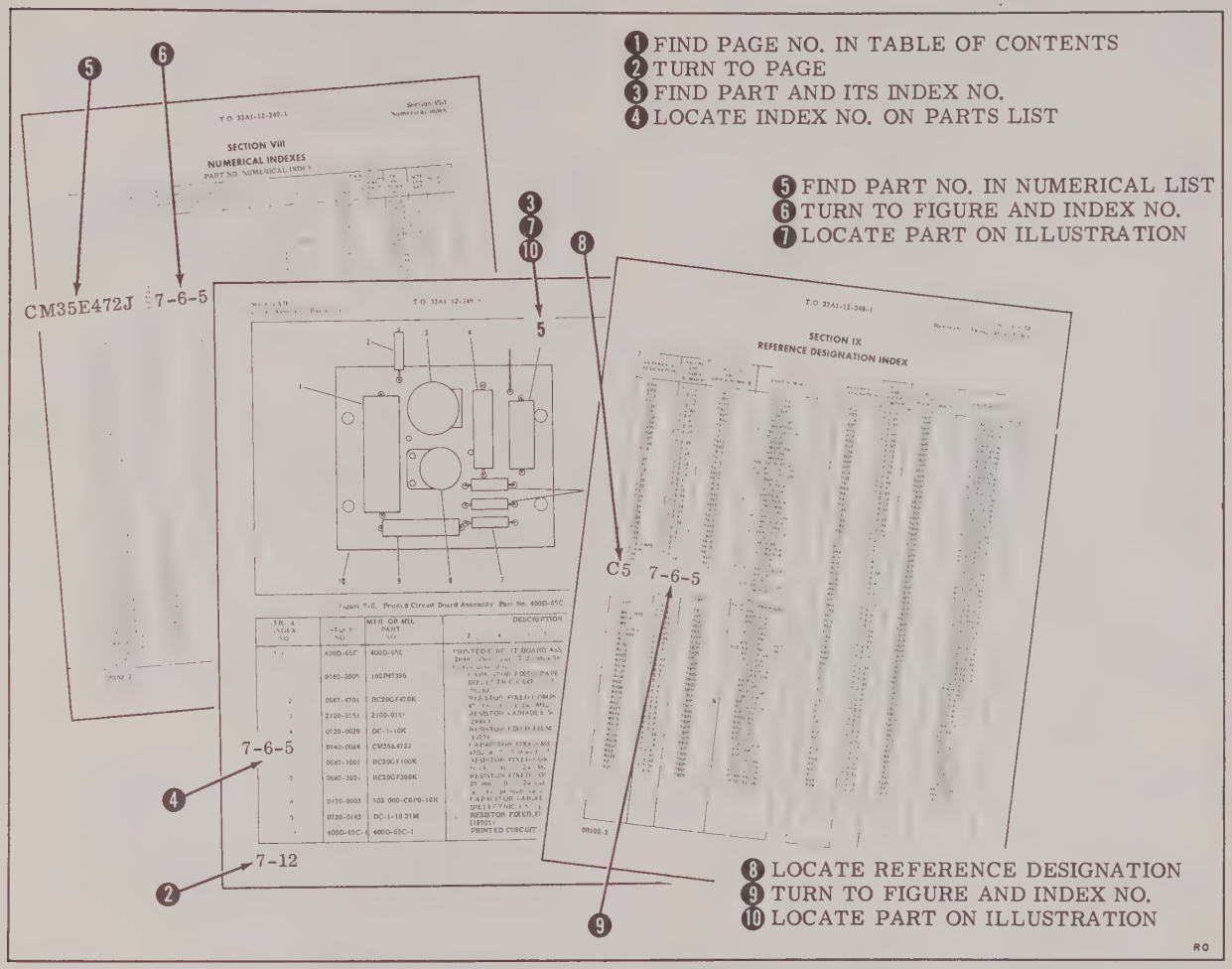
(1) CODE * applies to installation drawings, diagrams, instructions or field service drawings, basic drawing numbers which cannot be procured or manufactured, and obsolete parts.

6-14. VENDOR'S CODE. Vendor's code numbers have been assigned in accordance with Federal Supply Code H-4-1. The vendor's code appears in parentheses following the item name or within the description of each item in the Group Assembly Parts List (Section VII). The vendor's codes used in this Illustrated Parts Breakdown are listed below for convenience.

CODE	MANUFACTURER'S NAME AND ADDRESS
04009	ARROW-HART AND HEGEMAN ELECTRIC CO. 103 HAWTHORNE ST. HARTFORD, CONN., ZIP CODE 06106
08805	GENERAL ELECTRIC CO., LARGE LAMP DEPT. NELA PARK CLEVELAND, OHIO, ZIP CODE 44112
14493	HEWLETT-PACKARD CO. LOVELAND, COLO., ZIP CODE 80537
14655	CORNELL-DUBILIER ELECTRIC CORP. 50 PARIS STREET NEWARK, N. J.

CODE	MANUFACTURER'S NAME AND ADDRESS
14674	CORNING GLASS WORKS HOUGHTON PARK CORNING, N. Y., ZIP CODE 16701
19701	ELECTRA MFG. CO. 800 NORTH 21ST STREET INDEPENDENCE, KANS., ZIP CODE 67301
28520	HEYMAN MFG. CO. 147 N. MICHIGAN AVE. KENILWORTH, N. J.
35434	LECTROHM, INC. 5560 NORTHWEST HIGHWAY CHICAGO, ILL., ZIP CODE 60630
56289	SPRAGUE ELECTRIC CO. NORTH ADAMS, MASS.
70903	BELDEN MFG. CO. 415 SOUTH KILPATRICK CHICAGO, ILL., ZIP CODE 60644
71400	BUSSMANN MFG., DIVISION OF MCGRAW-EDISON CO. 2538 W. UNIVERSITY ST. ST. LOUIS, MO.
71785	CINCH MFG. CO. AND HOWARD B. JONES DIV. 1026 S. HOMAN AVE. CHICAGO, ILL.
72765	DRAKE MFG. CO. 4626 N. OLCOTT AVENUE CHICAGO, ILL., ZIP CODE 60656
72982	ERIE TECHNOLOGICAL PRODUCTS, INC. 644 W. 12TH ST. ERIE, PA., ZIP CODE 16512
73734	FEDERAL SCREW PRODUCTS, INC. 3917 N. KENZIE AVE. CHICAGO, ILL., ZIP CODE 60618
78189	SHAKEPROOF DIVISION OF ILLINOIS TOOL WORKS, INC. ST. CHARLES ROAD ELGIN, ILL., ZIP CODE 60120
81482	COOPERATIVE INDUSTRIES, INC. 100 OAKDALE RD. CHESTER, N. J.
82577	HUGHES AIRCRAFT CO. CULVER CITY, CALIF.
83330	SMITH, HERMAN H., INC. 812 SNEDIKER AVE. BROOKLYN, N. Y., ZIP CODE 11207
83380	BUCKLEY, C. E. 34 TREMAINE LEOMINSTER, MASS., ZIP CODE 01453
84411	TRW CAPACITOR DIVISION 112 W. FIRST ST. OGALLALA, NEBR.
85599	GENERAL ELECTRIC CO., TUBE DEPT. 1 RIVER ROAD SCHENECTADY, N. Y., ZIP CODE 12305
85628	KING ENGINEERING CO. BALTIMORE, MD.
85682	RINGEL BROS. 397 ELIZABETH AVE. NEWARK, N. J.
86684	RADIO CORP. OF AMERICA, ELECTRONIC COMPONENTS AND DEVICES HARRISON, N. J.
91506	AUGAT, INC. 33 PERRY AVE. ATTLEBORO, MASS., ZIP CODE 02703
91637	DALE ELECTRONICS, INC. P. O. BOX 609 COLUMBUS, NEBR., ZIP CODE 68601
91662	ELCO CORP. WILLOW GROVE, PA.
99849	ST. LOUIS BLOW PIPE AND HEATER CO., INC. 2000 N. 9TH ST. ST. LOUIS, MO.

HOW TO USE THIS ILLUSTRATED PARTS BREAKDOWN


1 FIND PAGE NO. IN TABLE OF CONTENTS
2 TURN TO PAGE
3 FIND PART AND ITS INDEX NO.
4 LOCATE INDEX NO. ON PARTS LIST
5 FIND PART NO. IN NUMERICAL LIST
6 TURN TO FIGURE AND INDEX NO.
7 LOCATE PART ON ILLUSTRATION
8 LOCATE REFERENCE DESIGNATION
9 TURN TO FIGURE AND INDEX NO.
10 LOCATE PART ON ILLUSTRATION
SECTION VIII
NUMERICAL INDEXES
SECTION IX
REFERENCE DESIGNATION INDEX
CM35E472J 7-6-5
7-6-5
7-12
C5 7-6-5
RO

HOW TO FIND THE PART NUMBER IF THE MAJOR ASSEMBLY IN WHICH THE PART IS USED IS KNOWN.

(1) Turn to the Table of Contents and find the page number for the major assembly in which the part is used.

(2) Turn to the page determined in step (1).

(3) Locate the part and its index number on the illustration.

(4) Find the index number on the Group Assembly Parts List page to determine the complete description.

HOW TO FIND THE ILLUSTRATION FOR A PART IF THE PART NUMBER IS KNOWN.

(5) Refer to the Part No. Numerical Index in Section VIII and find the part number.

(6) Turn to Section VII and find the first figure and index number that was indicated in the Part No. Numerical Index for that part. If this figure shows the part in a major assembly other than the one desired, refer to the other figure numbers listed in the Part No. Numerical Index.

(7) On the face of the illustration, find the index number determined in step (6).

HOW TO FIND THE PART AND ILLUSTRATION NUMBER FOR AN ELECTRONIC OR ELECTRICAL PART IF THE REFERENCE DESIGNATION IS KNOWN.

(8) Refer to Section IX, Reference Designation Index, and find the reference designation. The part number and the figure and index number will be shown in the right-hand columns opposite the reference designation.

(9) Turn to Section VII and find the figure and index number shown for the part in the "FIG. AND INDEX NO." column of the Reference Designation Index.

(10) On the face of the illustration, find the index number determined in step (9).

SECTION VII
GROUP ASSEMBLY PARTS LIST

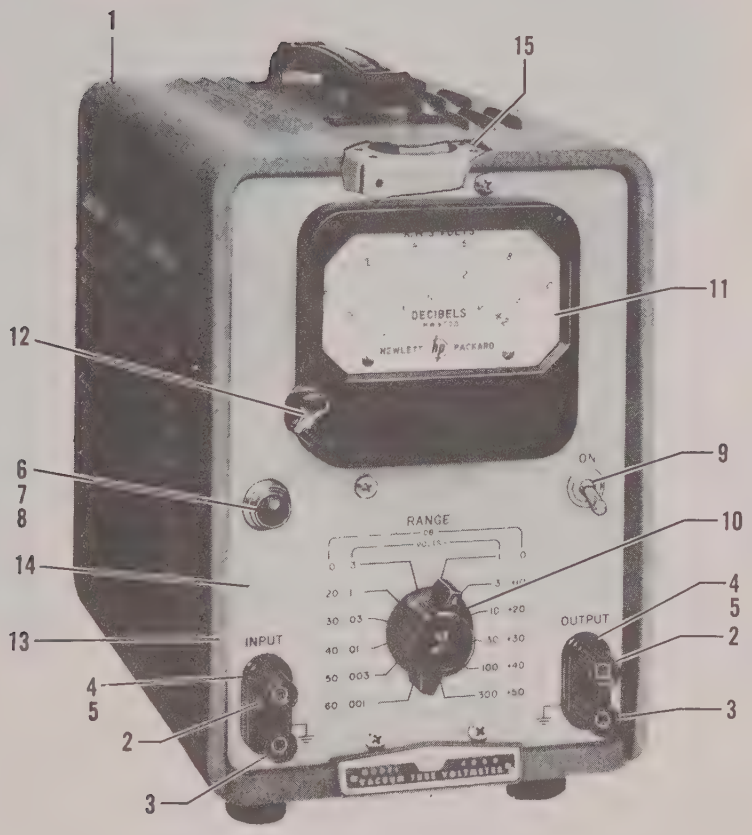


Figure 7-1. Model 400 Vacuum Tube Voltmeter Series (Sheet 1)

FIG. & INDEX NO.	PART NUMBER	1 2 3 4 5 6 7 DESCRIPTION	UNITS PER ASSY	USABLE ON CODE
7-1-	400D	VACUUM TUBE VOLTMETER (14493)	1	D
	400DR	VACUUM TUBE VOLTMETER (14493)	1	DR
	400H	VACUUM TUBE VOLTMETER (14493)	1	H
	400L	VACUUM TUBE VOLTMETER (14493)	1	L
	400HR	VACUUM TUBE VOLTMETER (14493)	1	HR
	400LR	VACUUM TUBE VOLTMETER (14493)	1	LR
	H02-400D	VACUUM TUBE VOLTMETER (14493)	1	H02
1	400D-44	. CABINET ASSEMBLY (14493)	1	D,H,L, H02
	5000-0627	. CABINET ASSEMBLY (14493)	1	DR,HR, LR
		(ATTACHING PARTS)		
	AN526-832-10	. SCREW, Machine	2	

---*---

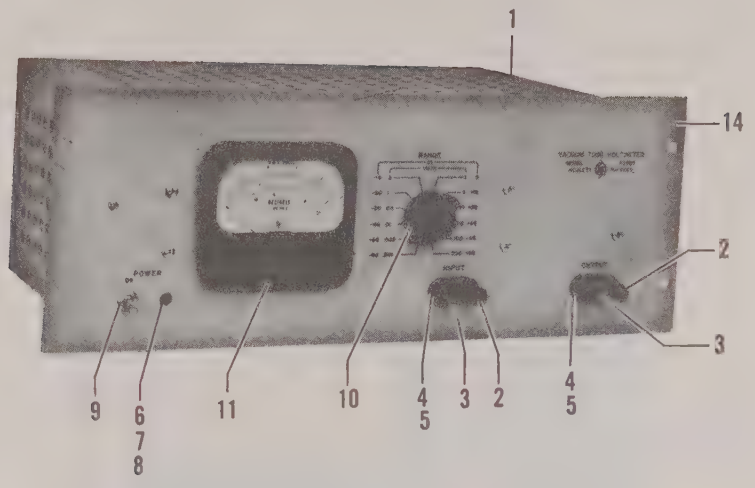


Figure 7-1. Model 400 Vacuum Tube Voltmeter Series (Sheet 2)

FIG. & INDEX NO.	PART NUMBER	1	2	3	4	5	6	7	DESCRIPTION	UNITS PER ASSY	USABLE ON CODE
7-1-	400D-1	.							PANEL ASSEMBLY, Front	1	D,H,L, HO2
	400DR-1	.							PANEL ASSEMBLY, Front	1	DR,HR, LR
									(ATTACHING PARTS)		
	AN526-832-8	.							SCREW, Machine	5	
	510-081810-01	.							NUT, Assembled washer (78189)	1	
									---*---		
- 2	5060-0634	.	.						POST, Binding, red (14493)	2	
- 3	5060-0635	.	.						POST, Binding, black (14493)	2	
- 4	0340-0089	.	.						INSULATOR, Standoff (14493)	2	
- 5	0340-0090	.	.						INSULATOR, Standoff (14493)	2	
- 6	14L-15	.	.						LENS, Indicator light (72765)	1	
- 7	12	.	.						LAMP, Incandescent, 6-8 volt, 2 pin base (08805)	1	
- 8	2020-AE	.	.						LAMPHOLDER, 2 Pin base (72765)	1	
- 9	80994-H	.	.						SWITCH, Toggle, spst (04009)	1	
- 10	0370-0035	.	.						KNOB (14493)	1	
- 11	1120-0005	.	.						MULTIMETER, Replacement (14993)	1	D,DR, HO2
	1120-0301	.	.						MULTIMETER, Replacement (14493)	1	H,HR
	1120-0098	.	.						MULTIMETER, Replacement (14493)	1	L,LR
- 12	1550	.	.						CLAMP, Loop (73734)	1	
- 13	5020-0137	.	.						BEZEL, Instrument mounting (14493)	1	D,H,L, HO2
									(ATTACHING PARTS)		
	AN515-6-4	.	.						SCREW, Machine	6	
									---*---		
- 14	400D-2	.	.						PANEL, Front (14493)	1	D,HO2
	400D-2R	.	.						PANEL, Front (14493)	1	DR
	400H-2A	.	.						PANEL, Front (14493)	1	H,L
	400H-2B	.	.						PANEL, Front	1	HR
	400L-2B	.	.						PANEL, Front	1	LR
- 15	400D-1C	.							MAIN CHASSIS ASSEMBLY (See figure 7-2) (14493)	1	

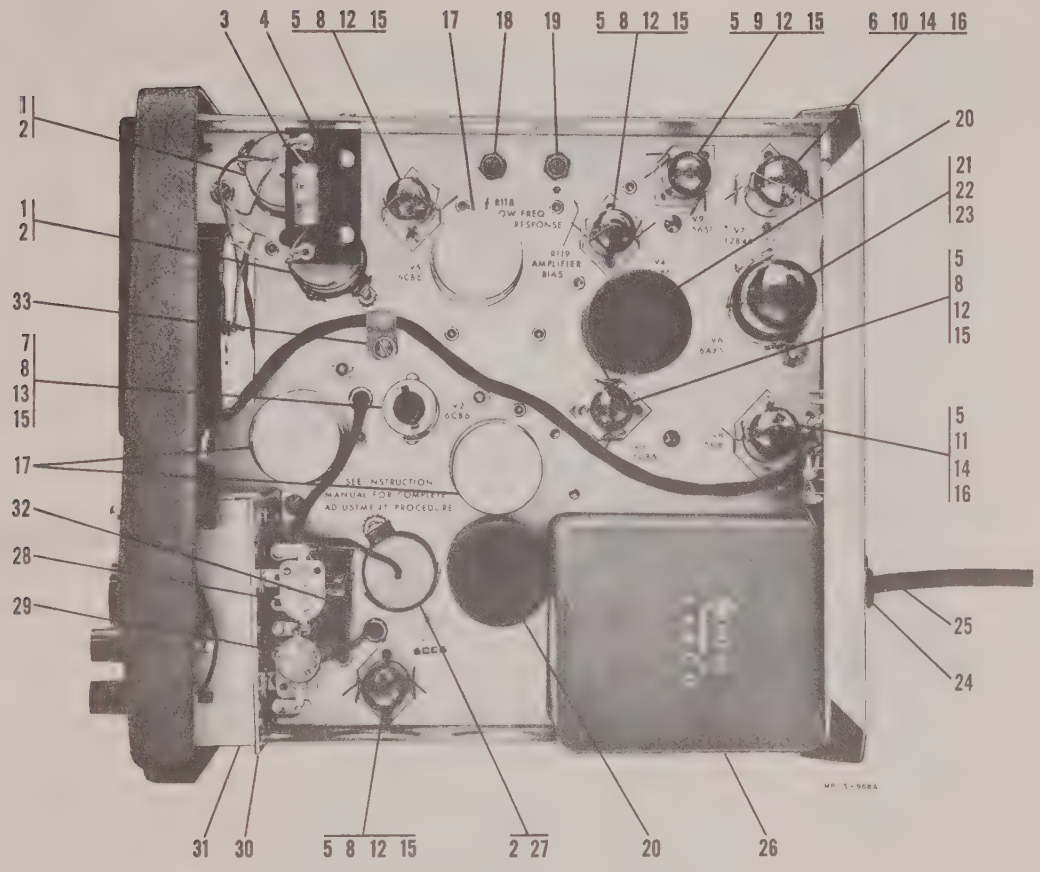


Figure 7-2. Main Chassis Assembly (Sheet 1)

FIG. & INDEX NO.	PART NUMBER	1 2 3 4 5 6 7 DESCRIPTION	UNITS PER ASSY	USABLE ON CODE
7-2-	400D-1C	MAIN CHASSIS ASSEMBLY (14493) . . . . . (See figure 7-1, index 15 for next higher assembly)	REF	
- 1	663UW20504	. CAPACITOR, Fixed, paper . . . . . dielectric, 2.0 uf ±20%, 400 vdcw (84411)	2	
- 2	INSULOID N3	. CLAMP, Loop (85628) . . . . . (ATTACHING PARTS)	3	
	510-061810-01	. NUT, Assembled washer (78189) . . . . . ---*---	3	
- 3	30D120A1	. CAPACITOR, Fixed, electrolytic, ... 500 uf plus 100%, minus 10%, 3 vdcw (56289)	1	D,DR, H02
	30D133A1	. CAPACITOR, Fixed, electrolytic, ... 50 uf, 600 vdcw (56289)	1	H,L, HR,LR
- 4	400D-75H	. BRACKET, Capacitor (14493) . . . . . (ATTACHING PARTS)	1	
	COML	. SCREW, Assembled washer, ... 6-32 by 3/8 in. lg, sst ---*---	1	
- 5	1400-0005	. RETAINER, Electron tube (14493)	6	
- 6	1400-0039	. RETAINER, Electron tube (14493)	1	
- 7	126	. SHIELD, Electron tube (91662)	1	

FIG. & INDEX NO.	PART NUMBER	1 2 3 4 5 6 7 DESCRIPTION	UNITS PER ASSY	USABLE ON CODE
7-2- 8	6CB6A	. ELECTRON TUBE (85599)	5	
- 9	5651	. ELECTRON TUBE (86684)	1	
- 10	12B4A	. ELECTRON TUBE (85599)	1	
- 11	6U8	. ELECTRON TUBE (85599)	1	
- 12	1400-0035	. RETAINER, Electron tube socket (14493)	5	
- 13	429-.125	. BASE, Tube shield (91662)	1	
- 14	1400-0034	. RETAINER, Electron tube socket (14493)	2	
- 15	316PH-3702	. SOCKET, Electron tube (91662)	6	
- 16	44F-16388	. SOCKET, Electron tube (71785)	2	
- 17	D32452	. CAPACITOR, Fixed, electrolytic, 4 section, 20 uf per section, 450 vdcw (56289)	3	
- 18	2100-0080	. RESISTOR, Variable, 1M ±30%, 0.2w (14493)	1	
- 19	2100-0136	. RESISTOR, Variable, 6K ±20%, 0.3w (14493)	1	
- 20	D27390	. CAPACITOR, Fixed, electrolytic, 2 section, 1500 uf per section, 15 vdcw (56289)	2	
- 21	6AX5-GT	. ELECTRON TUBE (86684)	1	
- 22	120D5-63AHS	. RETAINER, Electron tube (91506)	1	
- 23	51A12272	. SOCKET, Electron tube (71785)	1	
- 24	5P-1	. GROMMET, Plastic (28520)	1	
- 25	CS-9941/PH151/ 7.5 FT	. CABLE ASSEMBLY, Power, electrical (70903)	1	D,DR, H,L,HR, LR
	H02-400D-PWR-CORD	. CABLE ASSEMBLY, Power, electrical (14493)	1	H02
	CS-9941/PH151/ 7.5FTW/O PLUG	. . CABLE, Power, electrical (70903)	1	H02
	MS24663	. . CONNECTOR, Plug, electrical	1	H02
- 26	9100-0050	. TRANSFORMER, Power, step-down and step-up (14493) (ATTACHING PARTS)	1	
	510-101810-51	. NUT, Assembled washer (78189) ---*---	4	
- 27	S70375	. CAPACITOR, Fixed, paper dielectric, 5 uf ±10%, 100 vdcw (56289)	1	
- 28	503-000-B2P0-28R	. CAPACITOR, Variable, ceramic dielectric, 5-20 uuf, 500 vdcw (72982)	1	
- 29	503-000-D2P0-33R	. CAPACITOR, Variable, ceramic dielectric, 7-45 uuf, 500 vdcw (72982)	1	
- 30	400D-6J	. SHIELD, Rotary switch (14493) (ATTACHING PARTS)	1	
	COML	. SCREW, Assembled washer, 8-32 by 3/8 in. lg, sst ---*---	2	
- 31	400D-6K	. BRACKET, Angle (14493) (ATTACHING PARTS)	1	
	COML	. SCREW, Assembled washer, 6-32 by 3/8 in. lg, sst ---*---	2	
- 32	400D-19A	. RANGE SWITCH ASSEMBLY (14493) (See figure 7-3)	1	
- 33	INSULOID C3	. CLAMP, Loop (85682) (ATTACHING PARTS)	1	
	COML	. SCREW, Assembled washer, 6-32 by 3/8 in. lg, sst	1	
	AN960-6	. WASHER, Flat	1	
	510-061810-01	. NUT, Assembled washer (78189) ---*---	1	
- 34	PKM 4P5	. CAPACITOR, Fixed, paper dielectric, 0.5 uf ±10%, 400 vdcw (14655)	1	
- 35	781	. CLAMP, Loop (83330) (ATTACHING PARTS)	1	
	COML	. SCREW, Assembled washer, 6-32 by 1/2 in. lg, sst (78189)	1	
	510-061810-01	. NUT, Assembled washer (78189) ---*---	1	

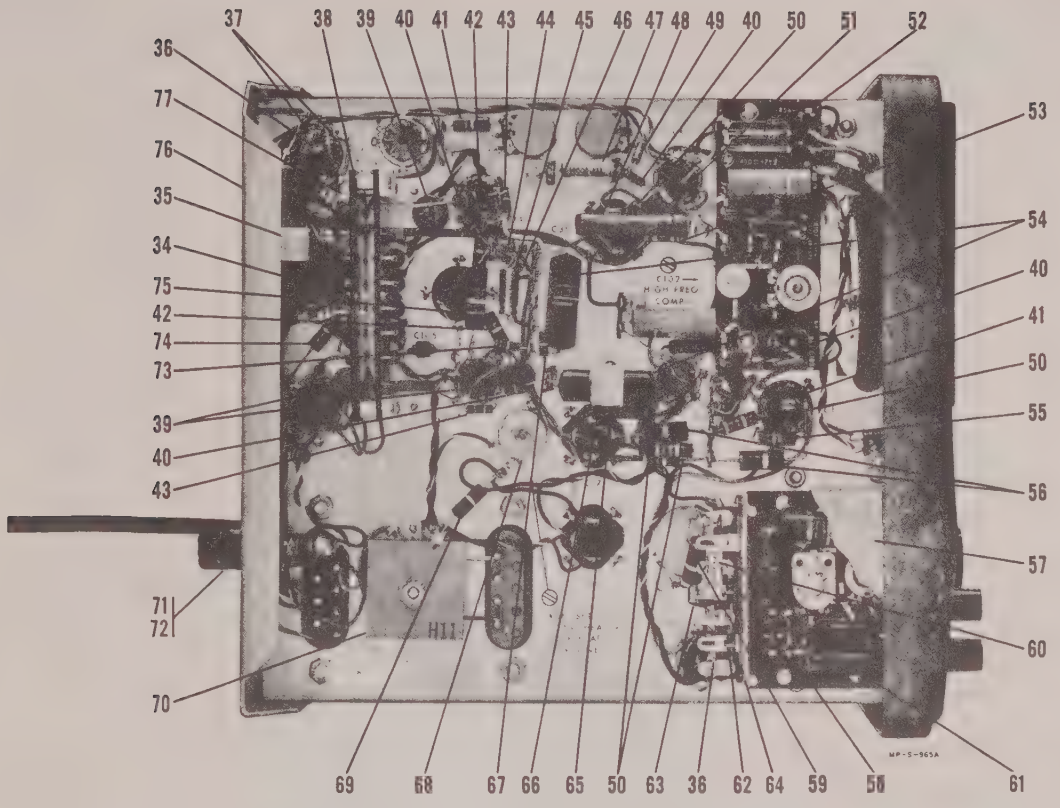


Figure 7-2. Main Chassis Assembly (Sheet 2)

FIG. & INDEX NO.	PART NUMBER	1 2 3 4 5 6 7 DESCRIPTION	UNITS PER ASSY	USABLE ON CODE
7-2- 36	RC20GF471K	. RESISTOR, Fixed, composition, ... 470 ohm ±10%, 1/2w (MIL-R-11)	2	
- 37	RC20GF474K	. RESISTOR, Fixed, composition, ... 470K ±10%, 1/2w (MIL-R-11)	2	
- 38	400D-75G	. PRINTED CIRCUIT BOARD ASSEMBLY . . . . . (14493) (See figure 7-4) (ATTACHING PARTS)	1	
	COML	. SCREW, Assembled washer, 6-32 by . . . . . 3/8 in. lg, sst ---*---	2	
- 39	29C214A3-H-1038	. CAPACITOR, Fixed, ceramic . . . . . dielectric, 0.01 uf ±20%, 1000 vdcw (56289)	3	
- 40	RC20GF470K	. RESISTOR, Fixed, composition, ... 47 ohm ±10%, 1/2w (MIL-R-11)	4	
- 41	RC32GF224K	. RESISTOR, Fixed, composition, ... 220K ±10%m, 1w (MIL-R-11)	2	
- 42	RC32GF2R7K	. RESISTOR, Fixed, composition, ... 2.7 ohm ±10%, 1w (MIL-R-11)	2	
- 43	RC20GF561K	. RESISTOR, Fixed, composition, ... 560 ohm ±10%m, 1/2w (MIL-R-11)	2	
- 44	RC20GF275K	. RESISTOR, Fixed, composition, ... 2.7 meg ±10%, 1/2w (MIL-R-11)	1	
- 45	30D133A1	. CAPACITOR, Fixed, electrolytic, ... 50 uf, 600 vdcw (56289)	1	

FIG. & INDEX NO.	PART NUMBER	1 2 3 4 5 6 7	DESCRIPTION	UNITS PER ASSY	USABLE ON CODE
7-2- 46	RC20GF104K	.	RESISTOR, Fixed, composition, ... 100K ±10%, 1/2w (MIL-R-11)	1	
- 47	148P22394	.	CAPACITOR, Fixed, plastic . . . . . dielectric, 0.020 uf ±10%, 400 vdcw (56289)	1	
- 48	C-10-6.3K	.	RESISTOR, Fixed, wire wound, ... 6.3K ±10%, 10w (35434)	1	
- 49	RC20GF684K	.	RESISTOR, Fixed, composition, ... 680K ±10%, 1/2w (MIL-R-11)	1	
- 50	RC32GF473K	.	RESISTOR, Fixed, composition, ... 47K ±10%, 1w (MIL-R-11)	4	
- 51	RC42GF103K	.	RESISTOR, Fixed, composition, ... 10K ±10%, 2w (MIL-R-11)	1	
- 52	400D-75F	.	PRINTED CIRCUIT BOARD ASSEMBLY . . . . . (14493) (See figure 7-5) (ATTACHING PARTS)	1	
	AN526-632-14	.	SCREW, Machine	2	
	AN935-6	.	WASHER, Lock	2	
	2102	.	SPACER, Sleeve (83330)	2	
	510-061810-01	.	NUT, Assembled washer (78189) . . . . . ---*---	2	
- 53	RC32GF332K	.	RESISTOR, Fixed, composition, ... 3.3K ±10%, 1w (MIL-R-11)	1	
- 54	160P10494	.	CAPACITOR, Fixed, paper . . . . . dielectric, 0.1 uf ±10%, 400 vdcw (56289)	2	
- 55	RC32GF114J	.	RESISTOR, Fixed, composition, ... 110K ±5%, 1w (MIL-R-11)	1	
- 56	RC42GF822K	.	RESISTOR, Fixed, composition, ... 8.2K ±10%, 2w (MIL-R-11)	2	
- 57	400D-6H	.	SHIELD, Input printed circuit board . . . . . assembly (14493) (ATTACHING PARTS)	1	
	510-061810-01	.	NUT, Assembled washer (78189) . . . . . ---*---	2	
- 58	400D-65C	.	PRINTED CIRCUIT BOARD ASSEMBLY . . . . . (14493) (See figure 7-6) (ATTACHING PARTS)	1	
	COML	.	SCREW, Assembled washer, 6-32 by . . . . . 3/8 in. lg, sst ---*---	2	
- 59	RC42GF682K	.	RESISTOR, Fixed, composition, ... 6.8K ±10%, 2w (MIL-R-11)	1	
- 60	148P47392	.	CAPACITOR, Fixed, plastic . . . . . dielectric, 0.047 uf ±10%, 200 vdcw (56289)	1	
- 61	RC20GF225K	.	RESISTOR, Fixed, composition, ... 2.2 meg ±10%, 1/2w (MIL-R-11)	1	
- 62	RC20GF825K	.	RESISTOR, Fixed, composition, ... 8.2 meg ±10%, 1/2w (MIL-R-11)	1	
- 63	160P10306	.	CAPACITOR, Fixed, paper dielectric, ... 0.01 uf ±20%, 400 vdcw (56289)	1	
- 64	400D-6F	.	MOUNTING PLATE, Shield (14493) . . . . . (ATTACHING PARTS)	1	
	510-061810-01	.	NUT, Assembled washer (78189) . . . . . ---*---	2	
- 65	777	.	CLAMP, Loop (83380) . . . . . (ATTACHING PARTS)	1	
	510-061810-01	.	NUT, Assembled washer (78189) . . . . . ---*---	2	
- 66	N25-8.2K	.	RESISTOR, Fixed, film, 8.2K ±5%, 1w . . . . . (14674)	1	
- 67	RC20GF125K	.	RESISTOR, Fixed, composition, ... 1.2 meg ±10%, 1/2w (MIL-R-11)	1	
- 68	2100-0077	.	RESISTOR, Variable, 4 ohm ±20%, 1w . . . . . (14493)	1	
- 69	RC32GF100K	.	RESISTOR, Fixed, composition, ... 10 ohm ±10%, 1w (MIL-R-11)	1	

FIG. & INDEX NO.	PART NUMBER	1 2 3 4 5 6 7	DESCRIPTION	UNITS PER ASSY	USABLE ON CODE
7-2- 70	61-6911	.	RECTIFIER, Metallic (81482)	1	
			(ATTACHING PARTS)		
	MS35239-42	.	SCREW, Machine	1	
	510-061810-01	.	NUT, Assembled washer (78189)	1	
			---*---		
- 71	MDL-1	.	FUSE, CARTRIDGE, 1 amp, 250v, slow	1	
			blow for 115v (71400)		
- 72	342003	.	FUSEHOLDER (71400)	1	
- 73	RC20GF335K	.	RESISTOR, Fixed, composition, ...	1	
			3.3 meg ±10%, 1/2w (MIL-R-11)		
- 74	RC32GF183K	.	RESISTOR, Fixed, composition, ...	1	
			18K ±10%, 1w (MIL-R-11)		
- 75	160P27296	.	CAPACITOR, Fixed, paper	1	
			dielectric, 0.0027 uf ±10%, 600 vdcw		
			(56289)		
- 76	400D-1A	.	PANEL, Rear (14493)	1	
- 77	400D-1B	.	CHASSIS, ELECTRICAL EQUIPMENT (14493)	1	

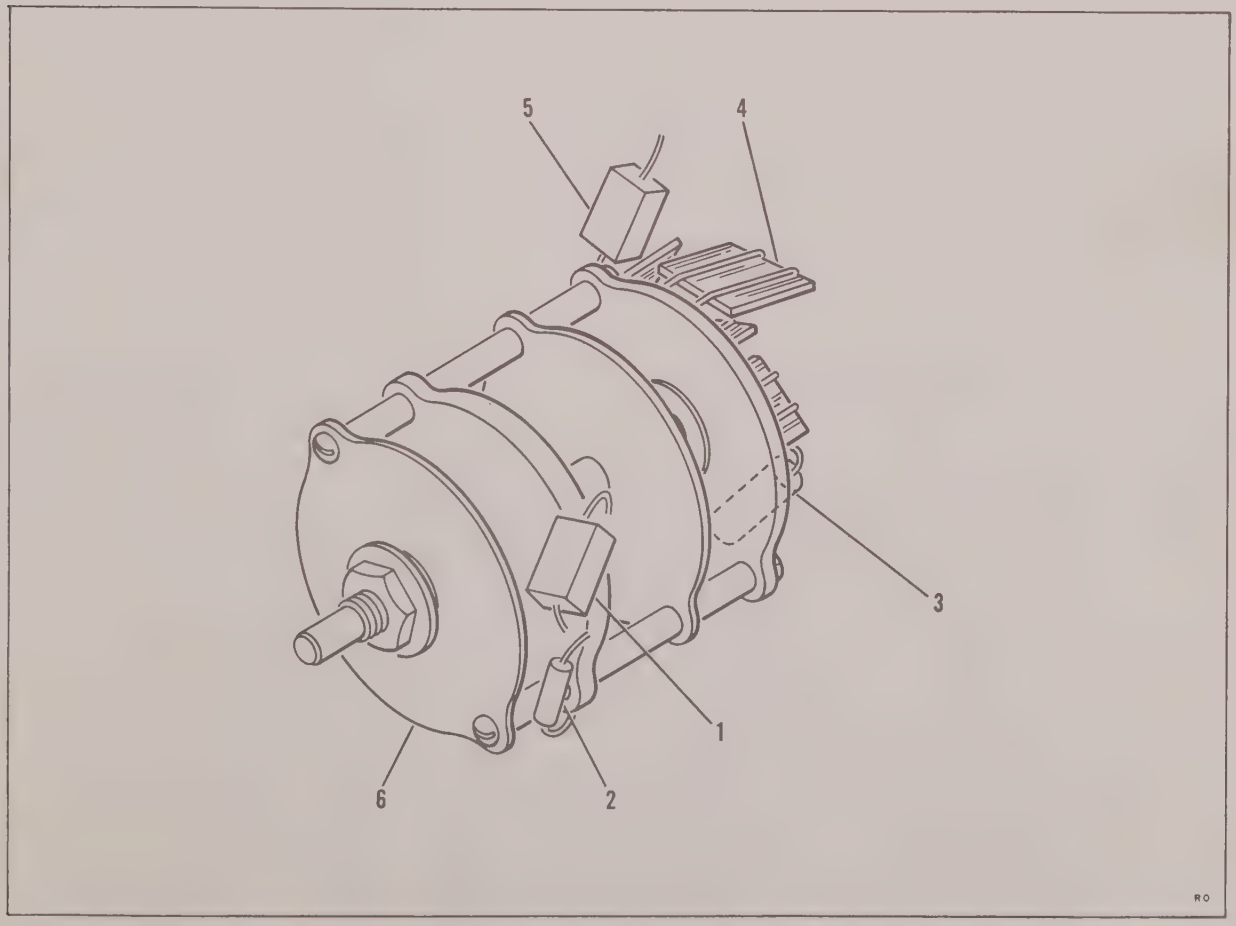


Figure 7-3. Range Switch Assembly

FIG. & INDEX NO.	PART NUMBER	1 2 3 4 5 6 7 DESCRIPTION	UNITS PER ASSY	USABLE ON CODE
7-3-	400D-19A	RANGE SWITCH ASSEMBLY (14493) . . . . . (See figure 7-2, index 32 for next higher assembly)	REF	
- 1	CM15E470J	. CAPACITOR, Fixed, mica dielectric, ... 47 uuf ±10%, 500 vdcw (MIL-C-5)	1	
- 2	RC20GF153K	. RESISTOR, Fixed, composition, ... 15K ±10%, 1/2w (MIL-R-11)	1	
- 3	315-000-C0G0-100D	. CAPACITOR, Fixed, ceramic . . . . . dielectric, 10 uuf ±0.5%, 500 vdcw (72982)	1	
- 4	400D-26G	. RESISTOR ASSEMBLY, Matched set of 6 . . . . . wire wound resistors, replaceable only as a set (14493)	1	
- 5	CM15E560J	. CAPACITOR, Fixed, mica dielectric, ... 56 uuf ±10%, 500 vdcw (MIL-C-5)	1	
- 6	3100-0251	. SWITCH, ROTARY, Not separately . . . . . replaceable (14493)	1	

FIG. & INDEX NO.	PART NUMBER	1 2 3 4 5 6 7 DESCRIPTION	UNITS PER ASSY	USABLE ON CODE
7-4-	400D-75G	PRINTED CIRCUIT BOARD ASSEMBLY . . . . . (14493) (See figure 7-2, index 38 for next higher assembly)	REF	
- 1	RC32GF683K	. RESISTOR, Fixed, composition, 68K ±10%, ... 1w (MIL-R-11)	1	
- 2	RC20GF104K	. RESISTOR, Fixed, composition, ... 100K ±10%, 1/2w (MIL-R-11)	1	
- 3	DC-1-90.5K	. RESISTOR, Fixed, film, 90.5K ±1%, 1w . . . . . (19701)	1	
- 4	DC-1-166K	. RESISTOR, Fixed, film, 166K ±1%, 1w . . . . . (19701)	1	
- 5	RC32GF124K	. RESISTOR, Fixed, composition, ... 120K ±10%, 1w (MIL-R-11)	1	
- 6	RC32GF563K	. RESISTOR, Fixed, composition, ... 56K ±10%, 1w (MIL-R-11)	1	
- 7	RC42GF184K	. RESISTOR, Fixed, composition, ... 180K ±10%, 2w (MIL-R-11)	1	
- 8	RC32GF334K	. RESISTOR, Fixed, composition, ... 330K ±10%, 1w (MIL-R-11)	1	
- 9	400D-75G-2	. PRINTED CIRCUIT BOARD (14493)	1	

FIG. & INDEX NO.	PART NUMBER	1 2 3 4 5 6 7	DESCRIPTION	UNITS PER ASSY	USABLE ON CODE
7-4- 10	CM20B681K	.	CAPACITOR, Fixed, mica dielectric, 680 pf ±10%, 500 vdcw (MIL-C-5)	1	
- 11	RC32GF242J	.	RESISTOR, Fixed, composition, 2.4K ±5%, 1w (MIL-R-11)	2	
- 12	RC42GF273K	.	RESISTOR, Fixed, composition, 27K ±10%, 2w (MIL-R-11)	4	
- 13	CM15E680K	.	CAPACITOR, Fixed, mica dielectric, 68 pf ±10%, 500 vdcw (MIL-C-5)	1	
- 14	42uh-10%-PHENOLIC FORM	.	COIL, RF, 42 uh ±10% (99849)	1	
- 15	400D-75G-1	.	PRINTED CIRCUIT BOARD (14493)	1	

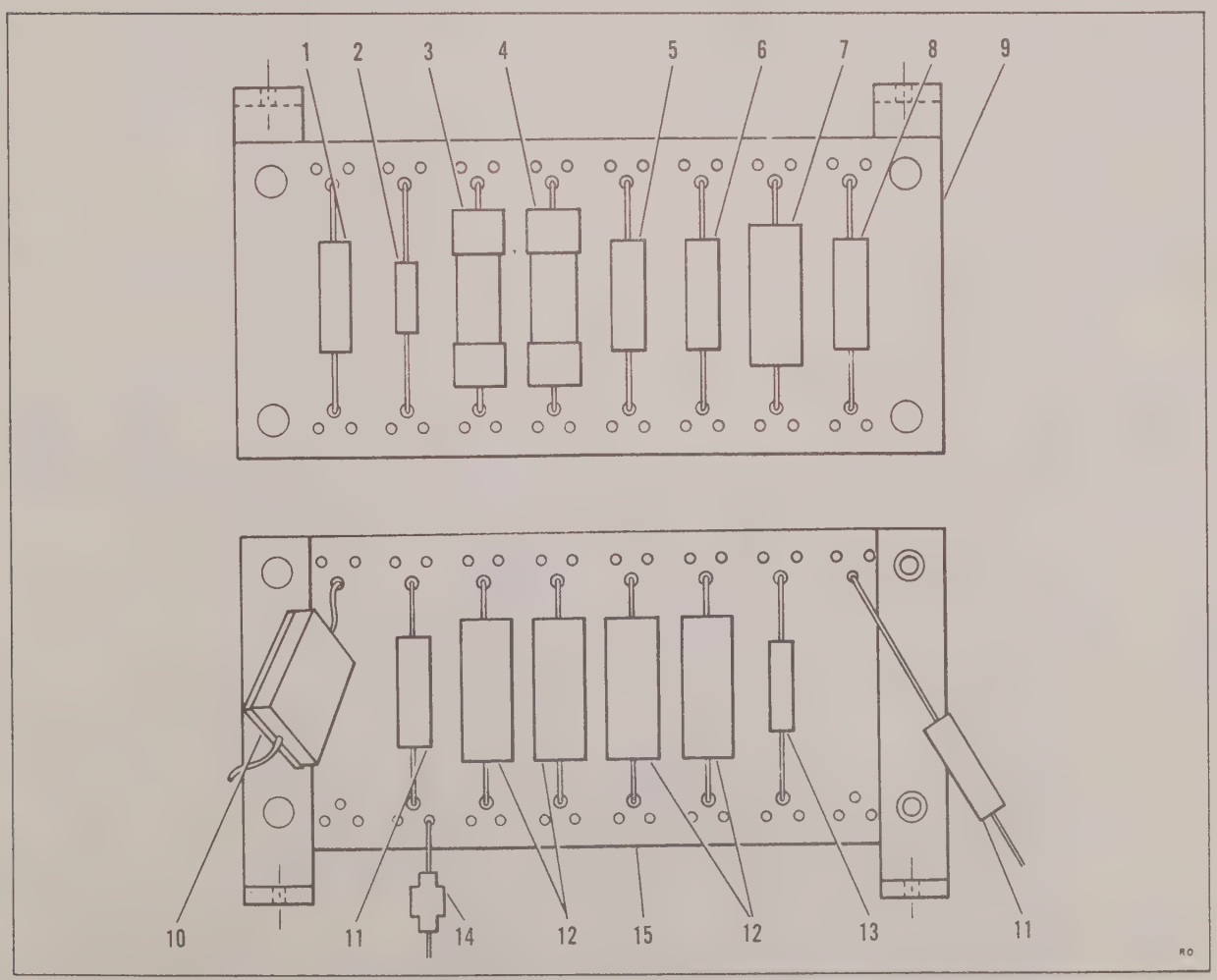


Figure 7-4. Printed Circuit Board Assembly, Part No. 400D-75G

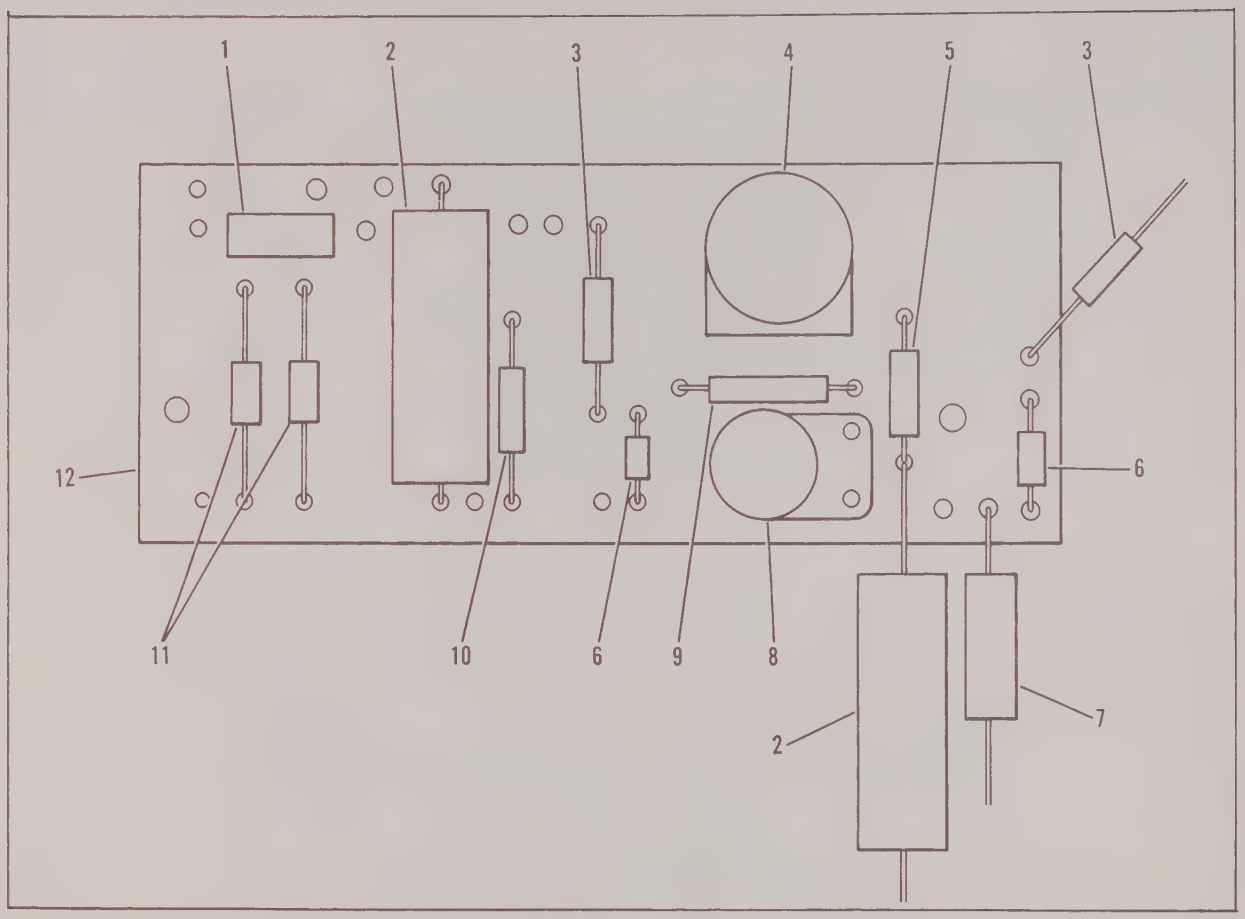


Figure 7-5. Printed Circuit Board Assembly, Part No. 400D-75F

FIG. & INDEX NO.	PART NUMBER	1 2 3 4 5 6 7	DESCRIPTION	UNITS PER ASSY	USABLE ON CODE
7-5-	400D-75F		PRINTED CIRCUIT BOARD ASSEMBLY . . . . . (14493) (See figure 7-2, index 52 for next higher assembly)	REF	
- 1	RC32GF510J	.	RESISTOR, Fixed, composition, ... 51 ohm ±5%, 1w(MIL-R-11)	1	
- 2	148P47491	.	CAPACITOR, Fixed, paper . . . . . dielectric, 0.47uf ±10%, 100 vdcw (56289)	2	
- 3	400D-26F	.	RESISTOR, Fixed, wire wound, ... 10 ohm ±0.5%, 1/2w (14493)	2	
- 4	2100-0108	.	RESISTOR, Variable, 100 ohm ±30%,1/3w . . . . . (14493)	1	
- 5	400D-26C	.	RESISTOR, Fixed, wire wound, ... 205 ohm ±0.5% (14493)	1	
- 6	400D-60A	.	COIL, Radio frequency, 0.05 uh (14493)	2	
- 7	CS-2-125	.	RESISTOR, Fixed, composition, ... 125 ohm ±10%, 2w (91637)	1	
- 8	557-000-U2P0-34R	.	CAPACITOR, Variable, ceramic . . . . . dielectric, 8-50 uuf, 350 vdcw (72982)	1	
- 9	DC-1/2C-40	.	RESISTOR, Fixed, film, ... 40 ohm ±1%, 1/2w (19701)	1	
- 10	RC20GF511J	.	RESISTOR, Fixed, composition, ... 510 ohm ±5%, 1/2w (MIL-R-11)	1	
- 11	HD-5004	.	SEMICONDUCTOR DEVICE, Diode (82577)	2	
- 12	400D-75F-1	.	PRINTED CIRCUIT BOARD (14493)	1	

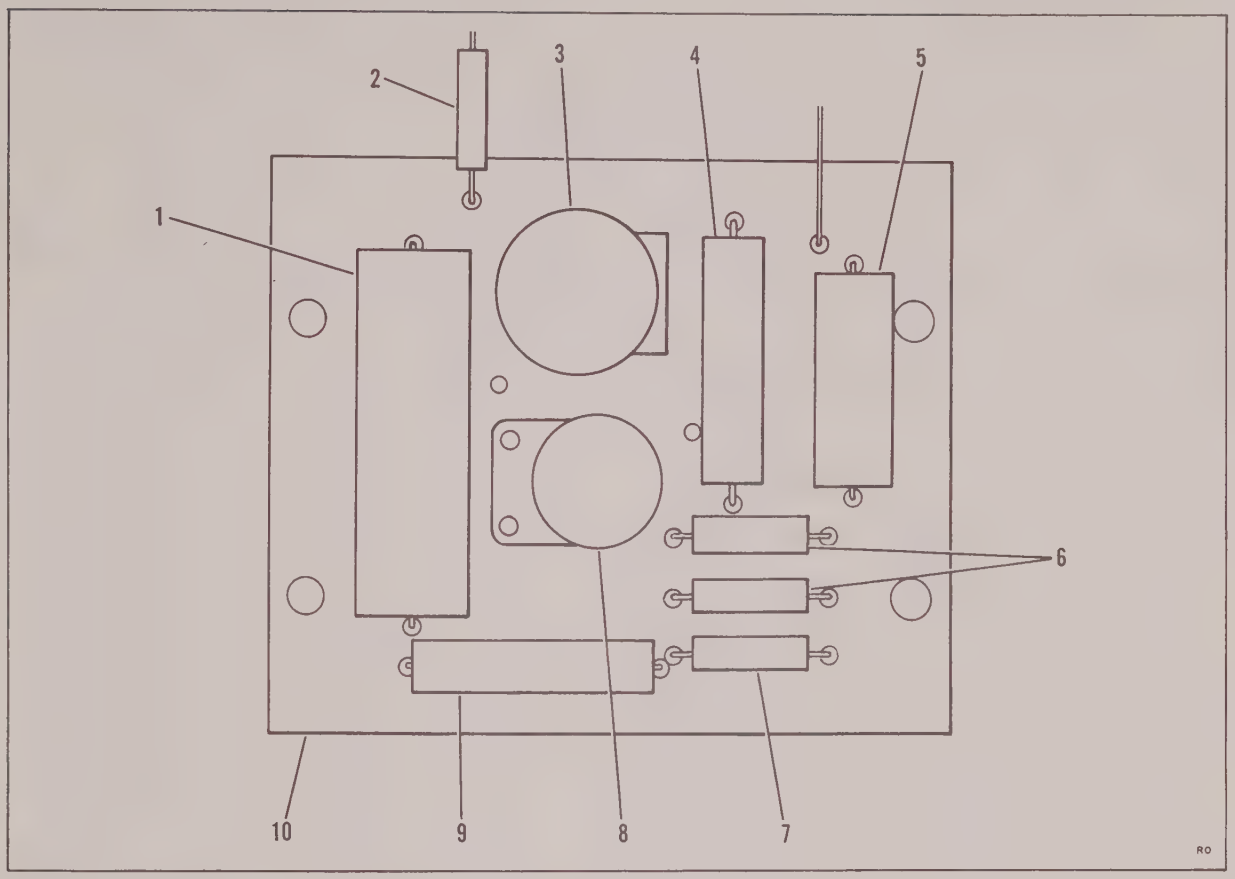


Figure 7-6. Printed Circuit Board Assembly, Part No. 400D-65C

FIG. & INDEX NO.	PART NUMBER	1 2 3 4 5 6 7	DESCRIPTION	UNITS PER ASSY	USABLE ON CODE
7-6-	400D-65C		PRINTED CIRCUIT BOARD ASSEMBLY . . . . . (14493) (See figure 7-2, index 58 for next higher assembly)	REF	
- 1	160P47396	.	CAPACITOR, Fixed, paper . . . . . dielectric, 0.047 uf ±10%, 600 vdcw (56289)	1	
- 2	RC20GF470K	.	RESISTOR, Fixed, composition, ... 47 ohm ±10%, 1/2w (MIL-R-11)	1	
- 3	2100-0151	.	RESISTOR, Variable, 500 ohm ±20%, 1/5w . . . . (14493)	1	
- 4	DC-1-10K	.	RESISTOR, Fixed, film, 10K ±1%, 1w . . . . . (19701)	1	
- 5	CM35E472J	.	CAPACITOR, Fixed, mica dielectric, ... 4700 uuf ±5%, 500 vdcw (MIL-C-5)	1	
- 6	RC20GF100K	.	RESISTOR, Fixed, composition, ... 10 ohm ±10%, 1/2w (MIL-R-11)	2	
- 7	RC20GF390K	.	RESISTOR, Fixed, composition, ... 39 ohm ±10%, 1/2w, value selected at factory, optimum value show (MIL-R-11)	1	
- 8	503-000-C0P0-10R	.	CAPACITOR, Variable, ceramic dielectric, . . . 1.5-7 uuf, 500 vdcw (72982)	1	
- 9	DC-1-10.31M	.	RESISTOR, Fixed, film, 10.3 meg ±1%, 1w . . . . (19701)	1	
- 10	400D-65C-1	.	PRINTED CIRCUIT BOARD (14493)	1	

SECTION VIII

NUMERICAL INDEX

PART NO.	FIG. AND INDEX NO.	QTY PER ART.	SOURCE CODE	REPAIR CODE
AN515-6-4	7-1-	6		
AN526-632-14	7-2-	2		
AN526-832-10	7-1-	2		
AN526-832-8	7-1-	5		
AN935-6	7-2-	2		
AN960-6	7-2-	1		
C-10-6.3K	7-2-48	1		
CM15E470J	7-3-1	1		
CM15E560J	7-3-5	1		
CM15E680K	7-4-13	1		
CM20B681K	7-4-10	1		
CM35E472J	7-6-5	1		
CS-2-125	7-5-7	1		
CS-9941/PH151/7.5FT	7-2-25	1		
CS-9941/PH151/7.5FT W/O PLUG	7-2-25	1		
DC-1/2C-40	7-5-9	1		
DC-1-10.31M	7-6-9	1		
DC-1-10K	7-6-4	1		
DC-1-166K	7-4-4	1		
DC-1-90.5K	7-4-3	1		
D27390	7-2-20	2		
D32452	7-2-17	3		
HD-5004	7-5-11	2		
H02-400D	7-1-	1		
H02-400D-PWR CORD	7-2-25	1		
INSULOID C3	7-2-33	1		
INSULOID N3	7-2-2	3		
MDL-1	7-2-71	1		
MS24663	7-2-25	1		
MS35239-42	7-2-	1		
N25-8.2K	7-2-66	1		
PKM 4P5	7-2-34	1		
RC20GF100K	7-6-6	2		
RC20GF104J	7-2-46	1		
RC20GF104K	7-4-2	1		
RC20GF125K	7-2-67	1		
RC20GF153K	7-3-2	1		
RC20GF225K	7-2-61	1		
RC20GF275K	7-2-44	1		
RC20GF335K	7-2-73	1		
RC20GF390K	7-6-7	1		
RC20GF470K	7-2-40	5		
	7-6-2			
RC20GF471K	7-2-36	2		
RC20GF474K	7-2-37	2		
RC20GF511J	7-5-10	1		
RC20GF561K	7-2-43	2		
RC20GF684K	7-2-49	1		
RC20GF825K	7-2-62	1		
RC32GF100K	7-2-69	1		
RC32GF114J	7-2-55	1		
RC32GF124K	7-4-5	1		
RC32GF183K	7-2-74	1		
RC32GF2R7K	7-2-42	2		
RC32GF224K	7-2-41	2		
RC32GF242J	7-4-11	2		
RC32GF332K	7-2-53	1		
RC32GF334K	7-4-8	1		

PART NO.	FIG. AND INDEX NO.	QTY PER ART.	SOURCE CODE	REPAIR CODE
RC32GF473K	7-2-50	4		
RC32GF510J	7-5-1	1		
RC32GF563K	7-4-6	1		
RC32GF683K	7-4-1	1		
RC42GF103K	7-2-51	1		
RC42GF184K	7-4-7	1		
RC42GF273K	7-4-12	4		
RC42GF682K	7-2-59	1		
RC42GF822K	7-2-56	2		
SCREW	7-2-	11		
S70375	7-2-27	1		
0340-0089	7-1-4	2		
0340-0090	7-1-5	2		
0370-0035	7-1-10	1		
1120-0005	7-1-11	1		
1120-0098	7-1-11	1		
1120-0301	7-1-11	1		
12	7-1-7	1		
12B4A	7-2-10	1		
120D5-63AHS	7-2-22	1		
126	7-2-7	1		
14L-15	7-1-6	1		
1400-0005	7-2-5	6		
1400-0034	7-2-14	2		
1400-0035	7-2-12	5		
1400-0039	7-2-6	1		
148P22394	7-2-47	1		
148P47392	7-2-60	1		
148P47491	7-5-2	2		
1550	7-1-12	1		
160P10306	7-2-63	1		
160P10494	7-2-54	2		
160P27296	7-2-75	1		
160P47396	7-6-1	1		
2020-AE	7-1-8	1		
2100-0077	7-2-68	1		
2100-0080	7-2-18	1		
2100-0108	7-5-4	1		
2100-0136	7-2-19	1		
2100-0151	7-6-3	1		
2102	7-2-	2		
29C214A3-H-1038	7-2-39	3		
30D120A1	7-2-3	1		
30D133A1	7-2-3	2		
	7-2-45			
3100-0251	7-3-6	1		
315-000-C0G0-100D	7-3-3	1		
316PH-3702	7-2-15	6		
342003	7-2-72	1		
400D	7-1-	1		
400D-1	7-1-1A	1		
400D-1A	7-2-76	1		
400D-1B	7-2-77	1		
400D-1C	7-1-15	1		
400D-19A	7-2-32	1		
400D-2	7-1-14	1		
400D-2R	7-1-14	1		
400D-26C	7-5-5	1		
400D-26F	7-5-3	2		

PART NO.	FIG. AND INDEX NO.	QTY PER ART.	SOURCE CODE	REPAIR CODE
400D-26G	7-3-4	1		
400D-44	7-1-1	1		
400D-6F	7-2-64	1		
400D-6H	7-2-57	1		
400D-6J	7-2-30	1		
400D-6K	7-2-31	1		
400D-60A	7-5-6	2		
400D-65C	7-2-58	1		
400D-65C-1	7-6-10	1		
400D-75F	7-2-52	1		
400D-75F-1	7-5-12	1		
400D-75G	7-2-38	1		
400D-75G-1	7-4-15	1		
400D-75G-2	7-4-9	1		
400D-75H	7-2-4	1		
400DR	7-1-	1		
400DR-1	7-1-1B	1		
400H	7-1-	1		
400H-2A	7-1-14	1		
400H-2B	7-1-14	1		
400H-2L	7-1-14	1		
400HR	7-1-	1		
400L	7-1-	1		
400LR	7-1-	1		
42uH-10%-PHENOLIC FORM	7-4-14	1		
429-.125	7-2-13	1		
44F-16388	7-2-16	2		
5P-1	7-2-24	1		
5000-0627	7-1-1	1		
5020-0137	7-1-13	1		
503-000-B2P0-28R	7-2-28	1		
503-000-C0P0-10R	7-6-8	1		
503-000-D2P0-33R	7-2-29	1		
5060-0634	7-1-2	2		
5060-0635	7-1-3	2		
51A12272	7-2-23	1		
510-061810-01	7-2-	12		
510-081810-01	7-1-	1		
510-101810-51	7-2-	4		
557-000-U2P0-34R	7-5-8	1		
5651	7-2-9	1		
6AX5-GT	7-2-21	1		
6CB6A	7-2-8	5		
6U8	7-2-11	1		
61-6911	7-2-70	1		
663UW20504	7-2-1	2		
777	7-2-65	1		
781	7-2-35	1		
80994-H	7-1-10	1		
9100-0050	7-2-26	1		

SECTION IX
REFERENCE DESIGNATION INDEX

REFERENCE DESIGNATION	FIGURE AND INDEX NUMBER	PART NUMBER
CR1	7-5-11	HD-5004
CR2	7-5-11	HD-5004
CR3	7-2-70	61-6911
C1	7-2-17	D32452
C100	7-2-63	160P10306
C101	7-2-60	148P47392
C102	7-5-8	557-000-U2P0-34R
C104	7-2-27	S70375
C105	7-2-20	D27390
C106	7-3-5	CM15E560J
C107	7-2-45	30D133A1
C108	7-3-1	CM15E470J
C14	7-2-28	503-000-B2P0-28R
C15	7-3-3	315-000-C0G0-100D
C16	7-2-29	503-000-D2P0-33R
C17	7-2-17	D32452
C19	7-2-54	160P10494
C2	7-6-1	160P47396
C20	7-5-2	148P47491
C22	7-4-10	CM20B681K
C23	7-2-54	160P10494
C24	7-2-75	160P27296
C25	7-2-39	29C214A3-H-1038
C26	7-4-13	CM15E680K
C28	7-2-47	148P22394
C29	7-2-39	29C214A3-H-1038
C30	7-2-17	D32452
C31	7-5-2	148P47491
C32	7-2-1	663UW20504
C33	7-2-1	663UW20504
C34	7-2-3	30D120A1
	7-2-3	30D133A1
C35	7-2-39	29C214A3-H-1038
C36	7-2-34	PKM 4P5
C39	7-2-20	D27390
C4	7-6-8	503-000-C0P0-10R
C5	7-6-5	CM35E472J
DS1	7-1-7	12
F1	7-2-71	MDL-1
L1	7-4-14	42μH-10%-PHENOLIC FORM
L10	7-5-6	400D-60A
L11	7-5-6	400D-60A
M1	7-1-11	1120-0005
	7-1-11	1120-0301
	7-1-11	1120-0098
P1	7-2-25	CS-9941/PH151/7.5FT
	7-2-25	H02-400D-PWR CORD
R1	7-2-55	RC32GF114J
R100	7-6-4	DC-1-10K
R101	7-6-3	2100-0151
R102	7-2-62	RC20GF825K
R103	7-2-61	RC20GF225K
R104	7-5-3	400K-26F
R105	7-5-5	400D-26C
R106	7-5-9	DC-1/2C-40
R107	7-5-4	2100-0108
R108	7-5-3	400D-26F
R110	7-3-2	RC20GF153K
R111	7-3-4	400D-26G
R112	7-3-4	400D-26G
R113	7-3-4	400D-26G
R114	7-3-4	400D-26G
R115	7-3-4	400D-26G
R116	7-3-4	400D-26G
R117	7-2-59	RC42GF682K
R118	7-2-18	2100-0080
R119	7-2-19	2100-0136
R120	7-2-41	RC32GF224K
R121	7-2-42	RC32GF2R7K
R122	7-2-42	RC32GF2R7K
R20	7-2-56	RC42GF822K
R21	7-2-50	RC32GF473K

REFERENCE DESIGNATION	FIGURE AND INDEX NUMBER	PART NUMBER
R22	7-2-56	RC42GF822K
R23	7-2-66	N25-8.2K
R24	7-2-40	RC20GF470K
R27	7-5-7	CS-2-12S
R30	7-2-67	RC20GF125K
R31	7-2-40	RC20GF470K
R32	7-2-50	RC32GF473K
R33	7-4-12	RC42GF273K
R34	7-4-12	RC42GF273K
R35	7-4-11	RC32GF242J
R36	7-2-73	RC20GF335K
R37	7-2-44	RC20GF275K
R38	7-2-43	RC20GF561K
R39	7-2-46	RC20GF104J
R4	7-6-9	DC-1-10.31M
R40	7-2-40	RC20GF470K
R41	7-2-50	RC32GF473K
R42	7-4-12	RC42GF273K
R43	7-4-12	RC42GF273K
R44	7-4-11	RC32GF242J
R47	7-2-43	RC20GF561K
R48	7-2-49	RC20GF684K
R49	7-2-40	RC20GF470K
R50	7-2-50	RC32GF473K
R51	7-2-53	RC32GF332K
R52	7-2-51	RC42GF103K
R53	7-5-10	RC20GF511J
R54	7-5-1	RC32GF510J
R55	7-4-7	RC42GF184K
R56	7-4-6	RC32GF563K
R57	7-2-48	C-10-6.3K
R58	7-4-5	RC32GF124K
R59	7-4-8	RC32GF334K
R6A	7-6-6	RC20GF100K
R6B	7-6-6	RC20GF100K
R6C	7-6-7	RC20GF390K
R60	7-2-74	RC32GF183K
R61	7-4-1	RC32GF683K
R62	7-4-4	DC-1-166K
R63	7-4-2	RC20GF104K
R64	7-4-3	DC-1-90.5K
R66	7-2-68	2100-0077
R67	7-2-36	RC20GF471K
R68	7-2-69	RC32GF100K
R7	7-2-41	RC32GF224K
R83	7-2-37	RC20GF474K
R85	7-2-37	RC20GF474K
R86	7-6-2	RC20GF470K
R9	7-2-36	RC20GF471K
S1	7-3-6	3100-0251
S2	7-1-9	80994-H
T1	7-2-26	9100-0050
V1	7-2-8	6CB6A
V2	7-2-8	6CB6A
V3	7-2-8	6CB6A
V4	7-2-8	6CB6A
V5	7-2-8	6CB6A
V6	7-2-21	6AX5GT
V7	7-2-10	12B4A
V8	7-2-11	6U8
V9	7-2-9	5651
XDS1	7-1-8	2020-AE
XF1	7-2-72	342003
XV1	7-2-15	316PH-3702
XV2	7-2-15	316PH-3702
XV3	7-2-15	316PH-3702
XV4	7-2-15	316PH-3702
XV5	7-2-15	316PH-3702
XV6	7-2-23	51A12272
XV7	7-2-16	44F-16388
XV8	7-2-16	44F-16388
XV9	7-2-15	316PH-3702

SECTION X

DIFFERENCE DATA SHEET

VACUUM TUBE VOLTMETER
PART NUMBER A11112-001
ELECTRONICS DIVISION OF GENERAL DYNAMICS
CONTRACT AF33(657)8260

The instructions contained in the previous sections of this manual apply except for the differences noted in this difference data sheet.

10—1. DESCRIPTION AND LEADING PARTICULARS

10-2. The Vacuum Tube Voltmeter, Electronics Division of General Dynamics Part Number A11112-001, is part of Aerospace Ground Equipment (AGE) for the F-111 Weapons System. Vacuum tube voltmeter A11112-001 is identical to Hewlett-Packard vacuum tube voltmeter Model 400DR except as follows:

a. Drawer stops and associated hardware were added to both sides of the unit.

b. Two handles and associated hardware were added to the front panel. The screws that secure the handles to the panel were coated with grade E locktite sealant (Military Specification MIL-P-11268 or equivalent).

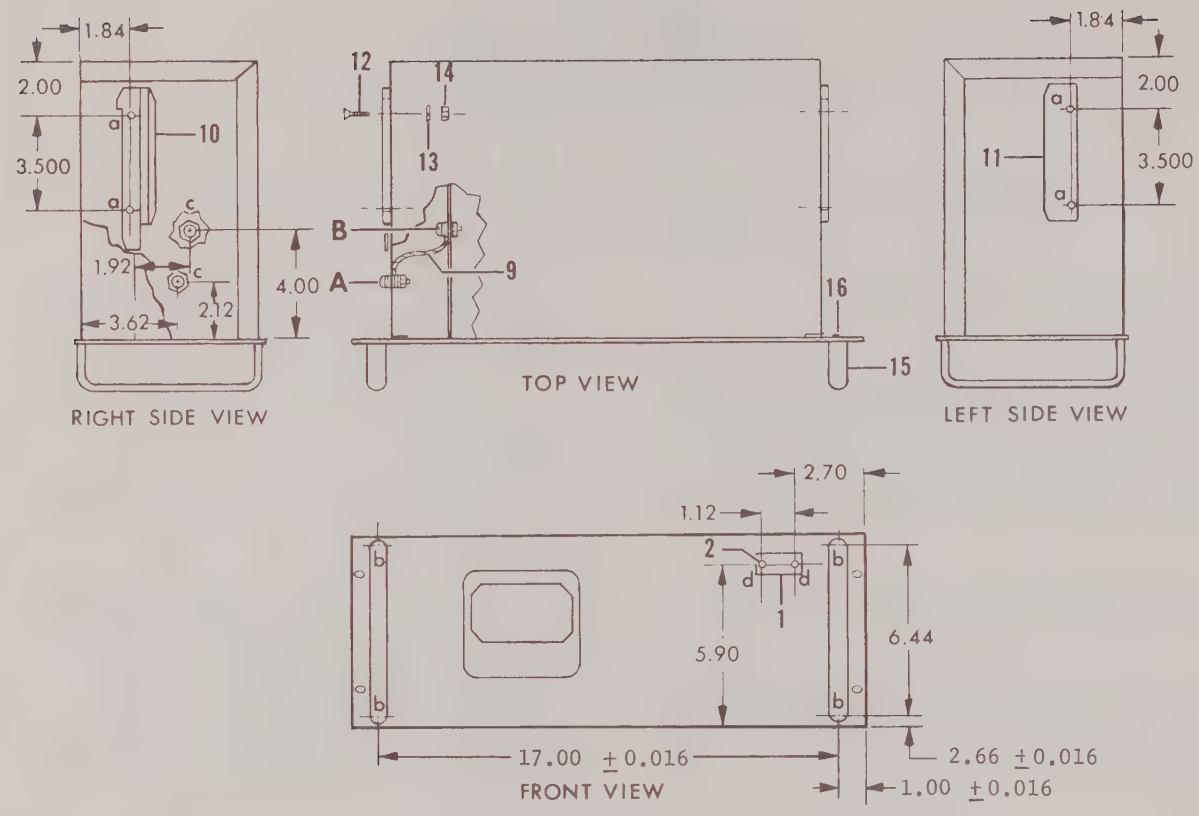
c. Two ground stud receptacles (jumpered with an electrical lead) and associated hardware were added to the left side of the unit.

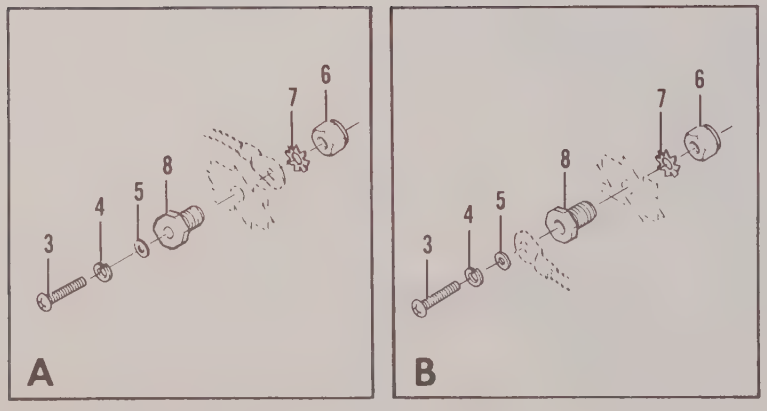
d. The new part number was marked on top of the unit in black paint (Federal Specification TT-E529, Class B).

e. All phenolic and organic parts were coated with fungicidal varnish in accordance with Military Specification MIL-T-152.

10-3. Operation and maintenance instructions for part number A11112-001 are the same as the operation and maintenance instructions for model 400D provided in the previous sections of this manual. Parts replacement information for part number A11112-001 is the same as the parts replacement information for model 400DR except for the addition of parts shown in the parts listing for figure 10-1.

FIG. & INDEX NO.	PART NUMBER	1 2 3 4 5 6 7 DESCRIPTION	UNITS PER ASSY
10-1-	A11112-001	VOLTMETER, Vacuum tube (58189) . . . . . (Altered from 28480 part number 400DR)	1
- 1	A22007-007	. NAMEPLATE (58189)	1
		(ATTACHING PARTS)	
- 2	MS24630-2	. SCREW, Panhead	2
		---*---	
- 3	MS35229-79	. SCREW, Panhead	2
- 4	MS35338-82	. WASHER, Split	2
- 5	AN961C416	. WASHER, Flat.	2
- 6	MS35691-830	. NUT, Hex.	2
- 7	MS35333-78	. WASHER, Innertooth, lock	2
- 8	A17825-001	. RECEPTACLE, Ground Stud (58189)	2
- 9	A18394-001	. LEAD, Electrical (58189).	1
- 10	A17710-001	. PAWL, Safety (58189).	1
- 11	A17752-001	. BLOCK, Guide (58189).	1
		(ATTACHING PARTS FOR INDEX NUMBER 10 AND 11)	
- 12	MS35249-37	. SCREW, Flathead	2
- 13	MS35338-79	. WASHER, Split	2
- 14	MS35649-64	. NUT, Hex	2
		---*---	
- 15	A15098-003	. HANDLE, Bow (58189)	2
		(ATTACHING PARTS)	
- 16	MS35250-72	. SCREW, Flathead	1
		---*---	





HOLE CHART		
HOLE	DESCRIPTION	QTY
a	0.177 DIA	4
b	0.228 DIA & CSK 82°X +0.010 0.392-0.000 DIA FS	4
c	0.515 DIA	2
d	0.078 DIA	2

T6817Q00-003A

Figure 10-1. Voltmeter A11112-001

SECTION XI

DIFFERENCE DATA SHEET

VACUUM TUBE VOLTMETER
MODELS 400D/DR SERIAL NUMBERS 310-45570 AND BELOW
MODELS 400H/HR AND 400L/LR SERIAL NUMBERS 313-22176 AND BELOW
MODELS 400L/LR SERIAL NUMBERS 048-13256 AND BELOW
MODELS 400H/HR SERIAL NUMBERS 017-12026 AND BELOW

The instructions contained in the previous sections of this manual apply except for the differences noted in this difference data sheet.

11—1. MANUAL CHANGES

11-2. To adapt this manual to instruments with other serial numbers, make changes as follows:

NOTE

These changes make this manual applicable to earlier instruments. Instrument component values that differ from those in this manual and are not listed in this section should be replaced using the part numbers given in this manual in the event of a component failure.

Model	Serial Prefix and Number	Make Manual Changes
400D/DR	310-45570 and below	1
400H/HR	313-22176 and below	1
400L/LR	313-22176 and below	1
400L	048-13256 and below	1, 2
400H	017-12026 and below	1, 3
400HR	017-12026 and below	1, 4
400LR	048-13256 and below	1, 4

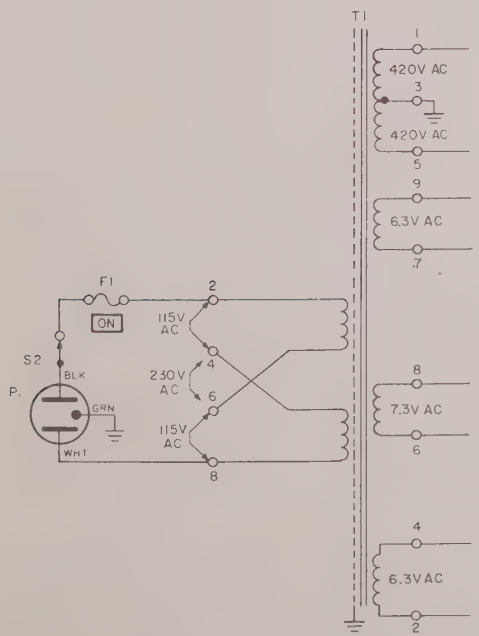


Figure 11-1. Power Transformer T-1

CHANGE #1 Section V, Figure 5-10, Voltmeter Schematic Diagram

CHANGE #2 Section VII, Figures 7-1-11 and 7-1-14
Multimeter, Replacement: Change Hewlett-Packard Part No. to read 1120-0081.
Panel, Front: Change Hewlett-Packard Part No. to read 400H-2.

Section VIII, Numerical Indexes
Change MFR. OR MIL. PART NO. 1120-0098 to read 1120-0081.
Change MFR. OR MIL. PART NO. 400H-2A to read 400H-2.

Section IX, Reference Designation Index
Change Reference Designation M1 L MFR. OR MIL. PART NO. and -HP- PART NUMBER to read 1120-0081.

CHANGE #3 Section VII, Figures 7-1-11 and 7-1-14
Multimeter, Replacement: Change Hewlett-Packard Part No. to read 1120-0048.
Panel, Front: Change Hewlett-Packard Part No. to read 400H-2.

Section VIII, Numerical Indexes
Change MFR. OR MIL. PART NO. 1120-0301 to read 1120-0048.
Change MFR. OR MIL. PART NO. 400H-2A to read 400H-2.

Section IX, Reference Designation Index
Change Reference Designation M1 H MFP. OR MIL. PART NO. and -HP- PART NUMBER to read 1120-0048.

CHANGE #4 Replacement Parts:
Multimeter Replacement: Change Hewlett-Packard Stock No. to read (HR) 1120-0048; (LR) 1120-0081.
Panel, Front: Change Hewlett-Packard Stock No. to read (HR) 400H-2R; (LR) 400L-2R.

11-3. When ordering replacement range switch assemblies use part numbers as follows:

MODEL	SERIAL PREFIX and NUMBER	RANGE SWITCH PART NUMBER
400D	017-34370 or below	400H-19W
400D	017-34371 or above	400D-19A
400 H/L	001-11226 or below	400H-19W
400 H/L	017-11227 or above	400D-19A

SECTION XII

DIFFERENCE DATA SHEET

VACUUM TUBE VOLTMETER MODEL C10-400D/DR

The instructions contained in the previous sections of this manual apply except for the differences noted in this difference data sheet.

12-1. DESCRIPTION AND LEADING PARTICULARS.

12-1. The Vacuum Tube Voltmeter Model C10-400D/DR is identical to the Model 400D/DR, except for two GR connectors which are added to the rear of the instrument. These connectors are wired in parallel with the INPUT and OUTPUT connectors on the front panel.

12-3. In all other respects this instrument is electrically identical to the Model 400D/DR Vacuum Tube Voltmeter. The basic portion of the manual covers operation, description, and service procedures.

12-4. The parts list in the basic manual applies to this instrument. Part Numbers for the added connectors are shown below.

PART NUMBER	DESCRIPTION	UNITS PER ASSEMBLY
0340-0086	Insulator	2
0340-0090	Insulator	2
1510-0006	Binding Post	2
1510-0007	Binding Post	2

SECTION XIII
DIFFERENCE DATA SHEET

VACUUM TUBE VOLTMETER MODEL C12-400DR

The instructions contained in the previous sections of this manual apply except for the differences noted in this difference data sheet.

13-1. DESCRIPTION AND LEADING PARTICULARS.

13-2. The Vacuum Tube Voltmeter Model C12-400DR is identical to the Model 400DR except for two BNC connectors which are added to the rear of the instrument. These connectors are wired in parallel with the INPUT and OUTPUT connectors on the front panel.

13-3. In all other respects this instrument is electrically identical to the Model 400D/DR Vacuum Tube Voltmeter. The basic portion of this manual covers operation, description, and service procedures.

13-4. The parts list in the basic manual applies to this instrument. Part numbers for the added connectors are shown below.

PART NUMBER	DESCRIPTION	UNITS PER ASSEMBLY
1250-0049	Nut	2
1250-0051	Connector	2
1250-0102	Body	2
0362-0027	Sleeve	2

SECTION XIV

DIFFERENCE DATA SHEET

VACUUM TUBE VOLTMETER MODELS 400D, 400H, AND 400L TEST, ADJUSTMENT, AND CERTIFICATION METHODS

The instructions contained in the previous sections of this manual apply except for the differences noted in this difference data sheet.

14-1. LEADING PARTICULARS

14-2. This difference data sheet is supplementary information and is to be used as an aid in testing and adjusting certain serial number Models 400D, 400H, and 400L Vacuum Tube Voltmeters. All circuit references apply to one of the three reference schematic diagrams. (See figures 14-1, 14-2, and 14-3.) All circuit changes are described in paragraph 14-3 (MODIFICATIONS) of this data sheet. Voltages mentioned herein are measured between the indicated points and the chassis, unless specified otherwise. The voltmeter power supply should always be tested before undertaking repair and adjustment of any other section of the instrument.

14-3. MODIFICATIONS

14-4. Modifications to certain serial numbered voltmeters, Models 400D, 400, and 400L, may have been made to simplify testing. The specifications of the instrument have not been changed. If modification of the instrument has been accomplished, it will simplify repair and testing and will add to instrument reliability. The changes that follow apply only to those 400D, 400H, and 400L instruments having those specified serial numbers.

A. Model 400D Serial Number 2221 and Below

V2 plate load resistor R23 has been changed from an 8200-ohm, ±5%, 1-watt, composition resistor to a metallic oxide film-type having the same resistance, tolerance, and wattage rating. This Corning Glass Works style N25 resistor is available under Stock No. 0761-0001.

This change has been recommended for those instruments in which the residual noise reading is too high and/or unstable. The new resistor has been mounted as nearly as possible in the same location as the old resistor.

B. Model 400D Serial Number 3944 and Below

Resistor R67 has been added in series with the control grid of the series regulator tube V7. The wire (usually green) from V7 pin 1 has been transferred to pin 6 on the same tube socket. A 470-ohm, ±10%, 1/2-watt composition resistor (Stock No. 0687-4711) has been added between V7 socket pins 1 and 6. The resistor prevents parasitic oscillation in the power supply. Such oscillation can cause the meter to be deflected full scale against the right-hand stop.

C. Model 400D Serial Number 4344 and Below.

A 10-ohm, ±10%, 1 watt, composition resistor (Stock No. 0690-1001), R68, has been connected in parallel with heater voltage adjustment control R66. This resistor reduces power dissipation in R66 and extends the life of the control. Readjust the dc heater voltage after installing R68.

D. Model 400D Serial Number 5130 and Below

The connections to electrolytic capacitor C30 has been transposed so that C30B is 20 μf and C30C is 40 μf. This transposition will reducé power supply ripple.

E. Model 400D Serial Number 14770 and Below, Model 400H Serial Number 1137 And Below

Whenever control R29 or three-section resistor R28 is replaced in the amplifier feedback circuit, a revised circuit kit has been installed in the voltmeter. The parts for this circuit revision are supplied as a kit with complete instructions under Stock No. 400D-95A.

The revised feedback circuit has been recommended for all 400D and 400H instruments whenever repair of the feedback circuit is necessary. The revised circuit is superior to earlier circuitry but does not offer sufficient advantages to warrant modification merely to include the new circuit in an instrument. The problem of adjusting frequency response following any changes in the feedback circuit would also make it advisable to avoid making unnecessary changes.

F. Model 400D Serial Number 16371 and Above, Model 400H Serial Number 1338 and Above

Series regulator tube V7 has been changed from a 6AU5 to a 12B4A. Control tube V8 has been changed from a 6CB6 to a 6U8 and reference tube V9 has been changed from an OB2 to a type 5651. The circuit differences can be determined by referring to the schematic diagrams. (See figures 14-1, 14-2, and 14-3.)

G. Model 400H Serial Number 1338 Through 1537

Resistor R83 has been changed in value and location. The new value is 470,000 ohms, ±10%, 1/2 watt instead of 100,000 ohms. A second resistor with a value of 470,000 ohms, ±10%, 1/2 watt and a schematic reference of R85 is connected in series with R83. The series combination of R83 and R85 is then connected between the regulated B+ output at the cathode of the regulator tube and chassis ground. The transformer winding supplying heater voltage for V6, V7, and V8 is connected to the junction of R83 and R85. These connections have been made by mounting both resistors between terminals on the socket for V7.

H. Model 400D Serial Number 17970 and Below, Model 400H Serial Number 2237 and Below

The input attenuator has been changed from a capacity divider to a resistive divider system by the addition of a kit of parts available under Stock No. 400D-95B. A higher degree of residual noise reduction is obtained on the upper voltmeter ranges by this modification.

I. Model 400D Serial Number 25970 and Below Model 400H/L Serial Number 5225 and Below

The value of resistor R45 is varied to control low frequency response if cathode resistors R38, R47, and R53 are changed from 120 ohms to 100 ohms, ±10%, 1 watt. The vtvm performance will be the same after changing the resistors but low frequency response adjustments are simplified.

14-5. TUBE AND CRYSTAL DIODE REPLACEMENT

14-6. Tubes with standard JEDEC characteristics can be used for replacement. In a great number of cases, instrument trouble can be traced to a defective or weak tube. Replace only those tubes proven to be defective or weak. Check tubes by substitution. Results obtained through the use of a "tube checker" can be erroneous and misleading. Mark original tubes to ensure that they are returned to the same socket if not replaced.

The power supply should be checked according to these instructions, after replacing V6, V7, V8, or V9 in the power supply.

Heater voltage must be checked and adjusted after replacing V1, V2, V3, or V4. Factory selected tubes are available for V1 and V2. These tubes are tested for low noise and microphonics.

Special high performance junction-type silicon diodes are available for replacement of diodes CR1 and CR2. These special diodes are available under part number 1901-0027.

The Stock No. 212-1N82S diodes once specified for CR1 and CR2 have been superseded by the superior 1901-0027 types. The cathode end of the diode has a gold-plated wire. The anode end of this diode has a silver-plated wire.

The 1901-0027 diode has a junction that is less than 1/2 mil in diameter. If the diodes are dropped, a mechanical failure may occur at the junction. After installation, the diodes will withstand any shock that the entire instrument can withstand.

Voltage calibration and frequency response should be checked and adjusted after replacing V1, V2, V3, V4, V5, CR1, or CR2.

14-7. TEST EQUIPMENT REQUIRED.

14-8. Test equipment required to test and calibrate Vacuum Tube Voltmeters 400D, 400H, and 400L is listed in Section V, figure 5-1.

14-9. TEST AND CALIBRATION PROCEDURE

14-10. When all the following procedures are to be completed, they can most easily be done in the order listed. In many instances, only one or two tests will be needed and they can be done without completing all other tests. For example, basic calibration can be checked and adjusted at any time without making any other adjustments.

A 10- to 15-minute warmup and a check of the power supply output voltages are recommended before making any other tests or adjustments.

The specifications for Model 400D, 400H, or 400L Vacuum Tube Voltmeter are given in Section I of this manual. The following test procedure contains extra checks to help analyze a particular instrument. These extra checks and the data they contain cannot be considered as specifications.

NOTE

The test frequencies and the voltages specified in many of the steps in this procedure are based upon the use of the test equipment listed in paragraph 14-8. Other frequencies and voltages can be used. Any vtvm can be adjusted for optimum performance on the range most commonly used.

A. Setting Mechanical Zero in Models 400D or 400H

1. Allow a 20-minute warmup for Model 400D. Turn instrument off.

2. Rotate mechanical zero-adjustment screw clockwise until meter pointer is to left of zero and moving upscale toward zero.

Continue to rotate adjustment screw clockwise; stop when pointer is right on zero. If pointer overshoots zero, repeat this adjustment.

3. When pointer is exactly on zero, rotate adjustment screw approximately 15 degrees counterclockwise. This is enough to free adjustment screw from the meter suspension. If pointer moves during this step, repeat entire adjustment.

B. Setting Mechanical Zero in Model 400L

The special meter in the 400L is adjusted with the vtvm turned on, since the meter pointer rests against the stop at the left end of the scale when the instrument is turned off.

In most 400L instruments the mechanical zero is preset during manufacture of the meter movement. The adjustment screw in such meters is inoperative. Most 400L instruments will have no adjusting screw on the front of the meter case.

The following procedure is for use only with those instruments in which the mechanical adjustment screw is effective.

1. Connect a 1.0-volt rms, 400 cps signal from the voltmeter calibrator to the 400L INPUT terminals. Set the 400L to the 1-volt range and adjust the feedback control (R29) for a full-scale meter reading of 1.0 volt. Any convenient range could also be used along with a corresponding change in input signal level. The input signal frequency is also not critical.

2. Switch the voltmeter calibrator to deliver a signal of 0.3 volt or 0.3 of the signal level used in step 1. Set the meter mechanical zero adjusting screw to obtain a reading that is 0.3 of the reference reading in step 1. Use the same vtvm range for both steps 1 and 2. If overshoot occurs, continue to rotate the screw clockwise and again approach the 0.3 point from the high side of the scale. The screw should not be turned counterclockwise during this procedure.

3. Repeat steps 1 and 2 until no further improvement can be noted. Compromise adjustment of the mechanical zero can be made for optimum tracking. After final adjustment, cover the screw with a small piece of black tape.

C. Check Regulated Power Supply

The regulated power supply check is performed using procedures in Section V, paragraph 5-21.

D. Set DC Heater Voltage

CAUTION

DO NOT USE A VOLTMETER THAT IS CONNECTED TO A COMMON GROUND WITH THE VTVM UNDER TEST WHEN MEASURING THESE HEATER VOLTAGES. A SHORT CIRCUIT WILL RESULT.

1. Adjust control R66 to set the dc heater voltage for tubes V1 and V2 to 6.3 volts ±0.2 volt. The dc voltages across the heaters of tubes V3 and V4 must also be 6.3 volts ±0.2 volt. Slight readjustment of control R66 will often bring these two voltages within tolerance.

2. If both voltages cannot be set to 6.3 volts ±0.2 volt, adjust R66 to bring the lowest of the two voltages within tolerance. Connect a resistor in parallel with the two heaters with the highest voltage. The correct resistor value will bring both heater voltages within tolerance by readjusting control R66. Use only one resistor in parallel with one pair of tubes at a time. A resistor value below 220 ohms, 1 watt should not be used.

3. If the correct heater voltage cannot be obtained after completing steps 1 and 2, check electrolytic capacitors in the heater circuit. If both heater voltages are low, check selenium rectifier SR1.

E. Input Divider Circuit Identification

1. An identification of the type of input circuit will enable the selection of the proper test required for the instrument. Instruments are classified by type of input circuit into two general groups:

a. Models 400D, serial 001-34370 and below; Models 400H/L, serial 001-11226 and below . . . these instruments may have either a "capacitive input divider" or a "resistive input divider." Complete steps 2 through 6 to determine which one is present.

b. Models 400D/H/L with serials prefixed 017- and 048- . . . all these instruments employ a "resistive divider." Omit steps 2 through 6.

2. Set the vtvm to the 1.0-volt range and connect a 1.0-volt rms, 400 cps signal from the voltmeter calibrator to the INPUT terminals. Any convenient range higher than the 1-volt range can be used. The signal frequency should be approximately 400 cps.

3. Rotate capacitor C4 (on input circuit board) one full turn while watching the vtvm meter reading. The meter reading will vary only about 5 percent in some instruments and approximately 50 percent in others.

4. If the meter indication varies approximately 50 percent, capacitor C4 is a Voltage Calibration Adjustment. This will be referred to as a "CAPACITIVE INPUT DIVIDER" circuit in the remainder of these procedures.

5. If the meter indication varies approximately 5 percent, capacitor C4 is a Frequency Response Adjustment. This will be referred to as a "RESISTIVE INPUT DIVIDER" circuit in the remainder of these procedures.

6. Mark the type of input circuit on the input circuit shield. This reference will be used in later steps of these procedures.

F. Basic Calibration (Setting Amplifier Gain)

1 For Models 400D serial 001-34370 and below and Models 400H/L serial 001-11226 and below:

Connect a 0.3-volt rms, 400 cps signal from the voltmeter calibrator to vtvm INPUT. Switch the vtvm to 0.3-volt range and adjust the feedback control, R29, to obtain a reading of 0.3 volt.

2 For Models 400D/H/L with serials prefixed 017- :

Connect a 0.001-volt rms, 400 cps signal from the voltmeter calibrator to vtvm INPUT. Switch the vtvm to the 0.001-volt range and adjust the feedback control, R107, to obtain a reading of 0.001 volt.

G. Basic Calibration (Setting Input Divider)

1 For Models 400D serial 001-34370 and below and Models 400H/L serial 001-11226 and below:

a. Connect a 1.0-volt rms, 400 cps signal from voltmeter calibrator to INPUT of vtvm. Switch vtvm to 1.0-volt range.

b. For "CAPACITIVE INPUT DIVIDER" circuits, adjust C4 for a reading of 1.0 volt.

c. For "RESISTIVE INPUT DIVIDER" circuits, the vtvm indication will normally be 1.0 volt. If reading is high, decrease value of pad (R87) in parallel with R3. If reading is low, increase value of pad (R87). Resistor R3 and pad R87 are on input circuit board.

2 For Models 400D/H/L with serials prefixed 017- .

a. Connect 1.0-volt rms, 400 cps, signal from voltmeter calibrator to INPUT of vtvm. Switch vtvm to 1.0-volt range.

b. Adjust R101 for a vtvm reading of 1.0 volt.

H. Miscellaneous Checks

NOTE

All checks in this section are made with the vtvm cabinet in place.

1. Noise and Switching Transients - This check will vary with the voltmeter model. Models 400D and 400H have one method while the 400L has a different method.

a. For 400D and 400H VOLTMETERS - Plug a shielded connector (Stock No. 1251-0019) over the INPUT terminals of the vtvm under test. A 100,000-ohm resistor should be connected between the terminals inside this shielded plug. The residual reading on the 0.001-volt scale will normally not be more than 0.00005 volt (5 percent of full scale).

b. For 400L VOLTMETER - Connect a 0.0003-volt rms (0.3-millivolt) signal of about 400 cps from the voltmeter calibrator to the INPUT terminals. The voltmeter reading should be steady with the range switch in the 0.001 position. Noise in V1 or V2 will cause this reading to vary erratically.

c. Connect the 100,000-ohm shielded resistor (see step a) between the INPUT terminals. Rotate the range switch through all 12 positions in both directions. The meter needle may be momentarily deflected as high as full scale between some switch positions. The meter pointer should always drop back to zero at a uniform rate without pause or a sudden change in the rate of fall.

d. Remove the shielded 100,000-ohm resistor and connect a 0.001-volt rms, 400 cps signal from the voltmeter calibrator to the INPUT terminals. The voltmeter reading should be steady with the range switch in the 0.001 position.

If the results obtained in this test are not satisfactory, check tubes V1 and V2, all coupling capacitors, electrolytic capacitors in screen and plate circuits, V2 plate load resistor, and cathode bypass capacitors.

2 Check for Microphonics

a. Connect a 0.001-volt rms, ac signal in the INPUT terminals and set the vtvm to the 0.001-volt range. Hold hand palm-upward and sharply rap the front of the meter case with knuckle. The pointer will usually not move more than about 1/8 inch along the meter scale.

b. Repeat step a at 300 volts on the 300-volt range. The results obtained should be the same.

Replace V1 and/or V2 to remove excessive microphonics.

3 Check Output vs Shock

a. Connect a 1.0-volt rms, ac signal to the INPUT and set the vtvm to the 1-volt range. Connect the vtvm OUTPUT to an oscilloscope and adjust oscilloscope to display several cycles.

b. Strike either top front corner of the instrument with the palm of hand. There should be no sudden change in amplitude nor a momentary collapse of the pattern. This test will detect another type of microphonic tube or poor electrical connections within the vtvm.

4 Check Beat Notes at 60 and 120 Cycles

a. Connect a battery-operated oscillator to the INPUT terminals of the vtvm. Set the range switch to the 1-volt range. Adjust the oscillator output to provide a vtvm reading of 0.9 volt at about 58 cps. Adjust the oscillator frequency to obtain maximum meter swing which will normally not be more than about 1/8 inch along the meter scale.

b. Repeat step a at 120 cps. The maximum meter swing will usually not be more than about 1/8 inch along the meter scale.

High beat notes are usually caused by defective tubes anywhere in the instrument.

I. Recheck DC Heater Voltage

Check the dc heater voltage by the method given in step D of this paragraph.

If either electrolytic capacitor in the heater circuit has been replaced, a heat-run of several hours should be allowed. After the heat-run to form the capacitor plates, reset the heater voltage.

J. Check Calibration And Tracking

1. Check full-scale accuracy of each voltmeter range. Use the voltmeter calibrator. The calibration should be within ±2 percent of full scale for a 400D Voltmeter or ±1 percent of full scale for a 400H or 400L Voltmeter. The test voltage should be between 50 cps and 500 kc. Avoid using the power line frequency or a harmonic of the power line. Refer to the accuracy specifications if you use a test frequency outside of this range.

2. Check meter tracking on any midrange. The 1-volt range is usually convenient. A sticky meter can cause the vtvm to be outside of the calibration specifications. Defective diodes for CR1 and CR2 can also introduce excessive tracking error.

K. Check Effect of Line Voltage Change

1. Connect a sine wave signal to the INPUT of the vtvm under test. Use a convenient midrange and adjust the input signal amplitude for a convenient reference level such as 0.9. Use any frequency within the frequency range of the voltmeter. The line voltage should be at 115 volts for at least 2 minutes before setting your reference level.

2. When the line voltage is changed from 115 to 103 or from 115 to 127 volts, the indication on the vtvm under test will normally not change from the reference level by more than ±2 percent of full scale after a 2-minute period.

These effects are more noticeable at the upper and lower limits of the vtvm frequency range. If the change is excessive, check tubes V5 through V1 in that order.

L. Frequency Response Adjustment

In most applications, frequency response adjustments will not be necessary, particularly if the vtvm is used at frequencies below approximately 500 kc. The results obtained will depend entirely upon the "reference voltmeter" used to monitor input signal level to the vtvm under test. Avoid making frequency response adjustments unless the frequency response characteristics of the reference voltmeter are accurately known. The following frequency response adjustment data is given for use in those cases where where frequency response is critical and the required test equipment is available.

The voltage at the input terminals of the vtvm under test must be monitored by the reference voltmeter. The reference voltmeter indication at 400 cps is called "reference level" in these instructions. The adjustments are listed in a sequence that is most convenient when using the Model 739AR and 200S instruments. If other equipment is used, change the sequence to suit the individual instrument.

1 For Models 400D serial 001-34370 and below and Models 400H/L serial 001-11226 and below:

NOTE

For Models 400D/H/L with serials prefixed 017-, proceed to step 2.

a. Adjust C21 at 4 mc on the 0.001-volt range after establishing a 400 cps "reference level" on the same range.

b. Adjust response at 1 mc on the 0.001-volt range. Use the same "reference level" as step a. Capacitor C26 in the plate circuit of V4 can be changed in value between limits of 15 and 82 pf to control 1 mc response. If C26 is changed, repeat step a.

c. Frequency response above 4 mc can be roughly adjusted by adding or adjusting the values of capacitor C40 and resistor R82 in the cathode circuit of V2.

If these parts are changed or added, repeat steps a and b. Use same range and reference level as step a. A response that "falls-off" above 4 mc is more desirable than one that rises.

d. The 10 to 20 cps response adjustment varies with voltmeter circuitry.

If cathode resistors R38, R47, and R53 for tubes V3, V4, and V5, respectively, all have values of 100 ohms, the value of R45 in the plate circuit of V4 can be adjusted between limits of 0.75 and 1.0 megohm to adjust the 10 to 20 cps response.

In any instrument, to increase the 10 cps indication, remove R80 if present in V2 grid circuit. Add R81 in V3 grid circuit if additional increase is needed after R80 removal. Conversely, to decrease the indication, remove R81 and add R80 if necessary. Either but not

both resistors can be added. Both resistors can be omitted. A value of 2.2 megohms or higher should be used for R80 or R81. Check tubes, cathode capacitor C20, and coupling capacitors if you find that a resistor value below 2.2 megohms is required.

e. Adjust C14 at 4 mc on the 0.003-volt range after establishing a 400 cps "reference level" on the same range.

f. Adjust C16 at 4 mc on the 0.01-volt range after establishing a 400 cps "reference level" on the same range.

g. Check frequency response on the 0.03, 0.1, and 0.3 volt ranges. Establish a 400 cps "reference level" for each range and then check response at 4 mc. If an error greater than ±5 percent of full scale is noted, make a compromise adjustment of C21. If you change C21, repeat steps a, b, c, d, e, and f. The compromise setting of C21 must be used when repeating step a.

h. For "CAPACITIVE INPUT DIVIDER" Circuits Omit step i.

i. For "RESISTIVE INPUT DIVIDER" Circuits Adjust C4 at 20 kc on the 1.0-volt range after establishing a 400 cps "reference level" on the same range.

j. Adjust R6 in the input divider to bring the 4 mc response within specifications on the 1.0-volt range after establishing a 400 cps "reference level" on the same range.

This resistor consists of several parallel resistors. Increasing the resistance of R6 will raise the response at 4 mc. Lowering the resistance will dedecrease the 4 mc response.

k. The response of the 3-volt range can now be checked. If other ranges have been properly adjusted, this range will be within specifications. The response of any range can now be checked at any frequency between 10 cps and 4 mc.

2 For Models 400D/H/L with serials prefixed 017- :

a. Adjust C102 "HIGH FREQUENCY COMP" at 4 mc on the 0.001-volt range after establishing a 400 cps "reference level" on the same range.

NOTE

Be sure reference meter is set at SET LEVEL.

b. The oscillator should now be turned through the band of 4 mc to 10 mc. Note the voltmeter indication during this time. If the reading increases more than 2 percent above the 4 mc level, adjust AMPLIFIER BIAS control R119 counterclockwise, and repeat 4 mc adjust (step a above). Repeat this procedure until peaking is less than 2 percent of the 4 mc response.

c. Set oscillator output to "reference level". Adjust LOW FREQUENCY RESPONSE control R118 to bring the 10 to 20 cps response within specified limits. If R118 will not bring both the 10- and 20-cycle response into specifications, the AMPLIFIER BIAS control R119 must be readjusted so that R118 can bring the 10- and 20-cycle response within limits.

d. If R119 is adjusted during the low frequency response calibration (step c), it will be necessary to repeat the high frequency response adjustment in step b. The adjustment of R119 will be a compromise to meet both low and high frequency specifications.

e. Adjust C14 at 4 mc on the 0.003-volt range after establishing a 400 cps reference level on the same range.

f. Adjust C16 at 4 mc on the 0.01-volt range after establishing a 400 cps reference level on the same range.

g. Adjust C4 at 20 kc on the 1.0-volt range after establishing a 400 cps reference level on the same range.

NOTE

Be sure input shield is in place before taking reading.

h. Adjust R6 in the input divider to bring the 4 mc response within specifications on the 1.0-volt range after establishing a 400 cps reference level on the same range. R6 consists of several resistors connected in parallel. Increasing the resistance of R6 will raise the frequency response at 4 mc. Lowering the resistance will decrease the 4 mc response.

M. Final Check and Adjustment

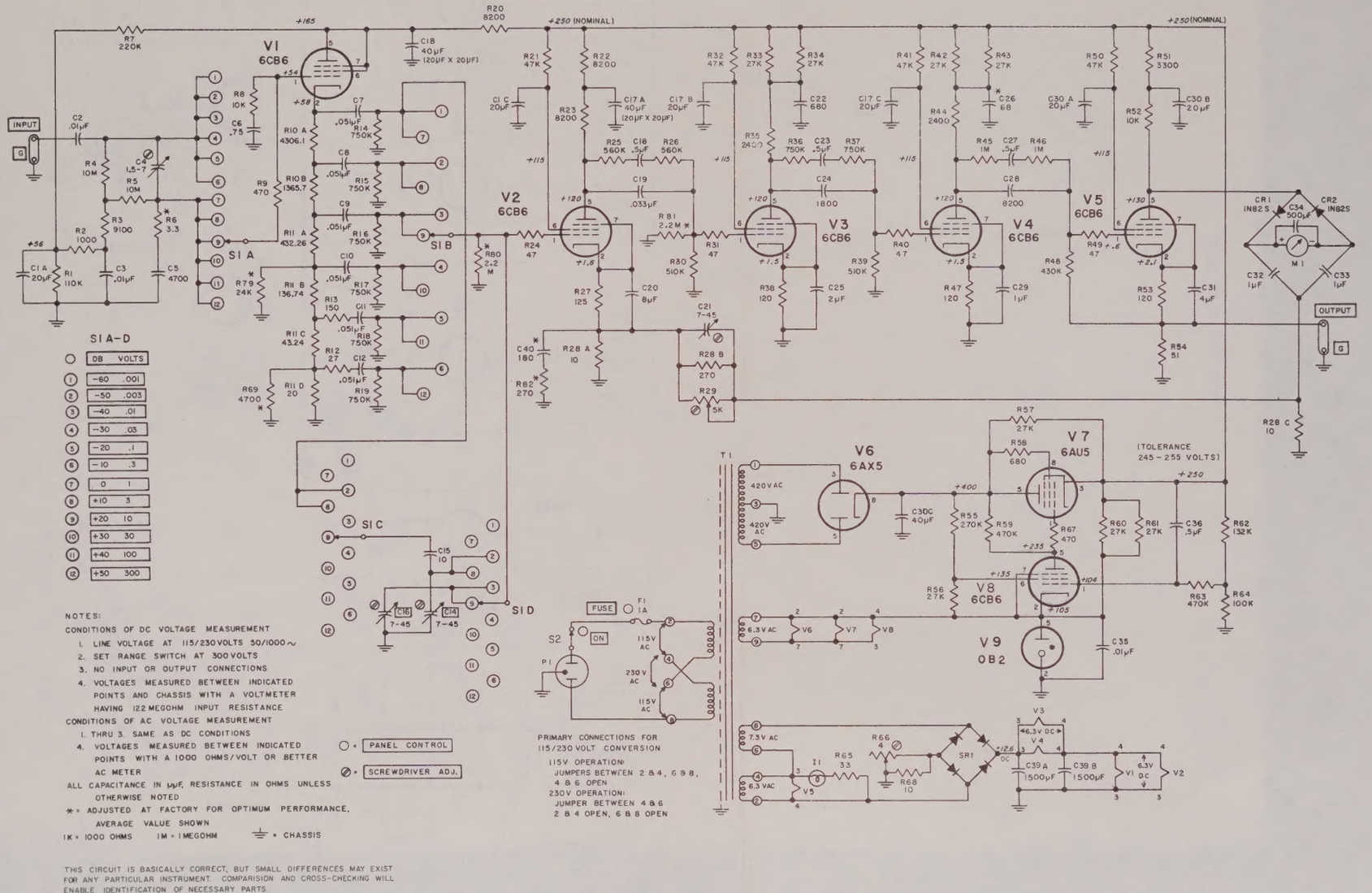
Repeat the Basic Calibration procedures given in steps F and G.

14-11. TEST FOR INSTRUMENT CERTIFICATION

14-12. To certify 400D, 400H, or 400L Vacuum Tube Voltmeter, it is only necessary to check the accuracy specifications. The specifications are given in Section I of this manual.

Certification is accomplished without removing the instrument cabinet and without making any instrument adjustments.

The procedures in steps J, K, and L contain adjustment methods. These adjustments must be omitted when certifying an instrument. Actually, if an instrument meets specifications, no adjustments will be necessary.


V1 6CB6
V2 6CB6
V3 6CB6
V4 6CB6
V5 6CB6
V6 6AX5
V7 6AU5
V8 6CB6
V9 0B2
SI A-D
DB VOLTS
-60 .001
-50 .003
-40 .01
-30 .03
-20 .1
-10 .3
0 1
+10 3
+20 10
+30 30
+40 100
+50 300
NOTES:
CONDITIONS OF DC VOLTAGE MEASUREMENT
1. LINE VOLTAGE AT 115/230 VOLTS 50/1000~
2. SET RANGE SWITCH AT 300 VOLTS
3. NO INPUT OR OUTPUT CONNECTIONS
4. VOLTAGES MEASURED BETWEEN INDICATED POINTS AND CHASSIS WITH A VOLTMETER HAVING 122 MEGOHM INPUT RESISTANCE
CONDITIONS OF AC VOLTAGE MEASUREMENT
1. THRU 3. SAME AS DC CONDITIONS
4. VOLTAGES MEASURED BETWEEN INDICATED POINTS WITH A 1000 OHMS/VOLT OR BETTER AC METER
ALL CAPACITANCE IN µµF, RESISTANCE IN OHMS UNLESS OTHERWISE NOTED
* = ADJUSTED AT FACTORY FOR OPTIMUM PERFORMANCE, AVERAGE VALUE SHOWN
1K = 1000 OHMS 1M = 1 MEGOHM = CHASSIS
= PANEL CONTROL
= SCREWDRIVER ADJ.
PRIMARY CONNECTIONS FOR 115/230 VOLT CONVERSION
115V OPERATION: JUMPERS BETWEEN 2 8 4, 6 9 8, 4 8 6 OPEN
230V OPERATION: JUMPER BETWEEN 4 8 6 2 8 4 OPEN, 6 8 8 OPEN
THIS CIRCUIT IS BASICALLY CORRECT, BUT SMALL DIFFERENCES MAY EXIST FOR ANY PARTICULAR INSTRUMENT. COMPARISION AND CROSS-CHECKING WILL ENABLE IDENTIFICATION OF NECESSARY PARTS.
INPUT
OUTPUT
FUSE F1 1A
S2 ON
P1
T1
SR1
M1
(TOLERANCE 245 - 255 VOLTS)

T6817Q00-007

Figure 14-1. Schematic Diagram With "Capacitive Input Divider" Circuit, Original Feedback Circuit, and Original Power Supply Circuit

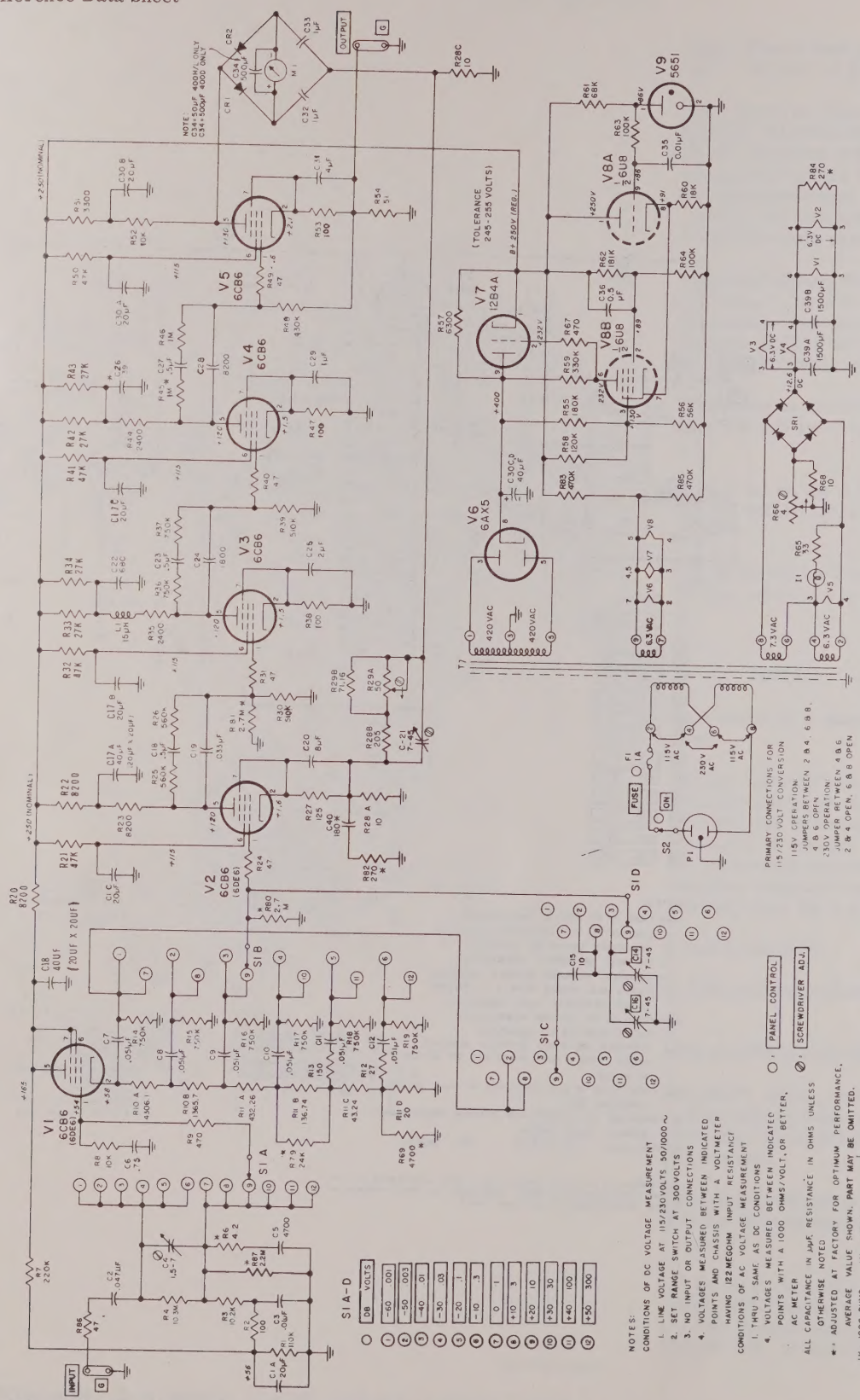

V1 6CB6 (6DE6)
V2 6CB6 (6DE6)
V3 6CB6
V4 6CB6
V5 6CB6
V6 6AX5
V7 12B4A
V8 16U8
V9 5651
S1A
S1B
S1C
S1D
S2
P1
J1
T1
SR1
INPUT
OUTPUT
FUSE
ON
420 VAC
6.3 VAC
7.3 VAC
115V AC
230 V AC
+250 NOMINAL
(TOLERANCE 245-255 VOLTS)
B+ 250V (REG.)
+400
PANEL CONTROL
SCREWDRIVER ADJ.
PRIMARY CONNECTIONS FOR 115/230 VOLT CONVERSION
115V OPERATION: JUMPERS BETWEEN 2 & 4, 6 & 8, 4 & 6 OPEN
230V OPERATION: JUMPER BETWEEN 4 & 6, 2 & 4 OPEN, 6 & 8 OPEN
NOTES:
CONDITIONS OF DC VOLTAGE MEASUREMENT
1. LINE VOLTAGE AT 115/230 VOLTS 50/1000 ~
2. SET RANGE SWITCH AT 300 VOLTS
3. NO INPUT OR OUTPUT CONNECTIONS
4. VOLTAGES MEASURED BETWEEN INDICATED POINTS AND CHASSIS WITH A VOLTMETER HAVING 22 MEGOHM INPUT RESISTANCE
CONDITIONS OF AC VOLTAGE MEASUREMENT
1. THRU 3 SAME AS DC CONDITIONS
4. VOLTAGES MEASURED BETWEEN INDICATED POINTS WITH A 1000 OHMS/VOLT, OR BETTER, AC METER
ALL CAPACITANCE IN µµF, RESISTANCE IN OHMS UNLESS OTHERWISE NOTED
*- ADJUSTED AT FACTORY FOR OPTIMUM PERFORMANCE, AVERAGE VALUE SHOWN. PART MAY BE OMITTED.
1K = 1000 OHMS 1M = 1MEGOHM * = CHASSIS
THIS CIRCUIT IS BASICALLY CORRECT, BUT SMALL DIFFERENCES MAY EXIST FOR ANY PARTICULAR INSTRUMENT. COMPARISION AND CROSS-CHECKING WILL ENABLE IDENTIFICATION OF NECESSARY PARTS.
T6817Q00-008

Figure 14-2. Schematic Diagram With "Resistive Input Divider" Circuit, Revised Feedback Circuit, and Modified Power Supply Circuit

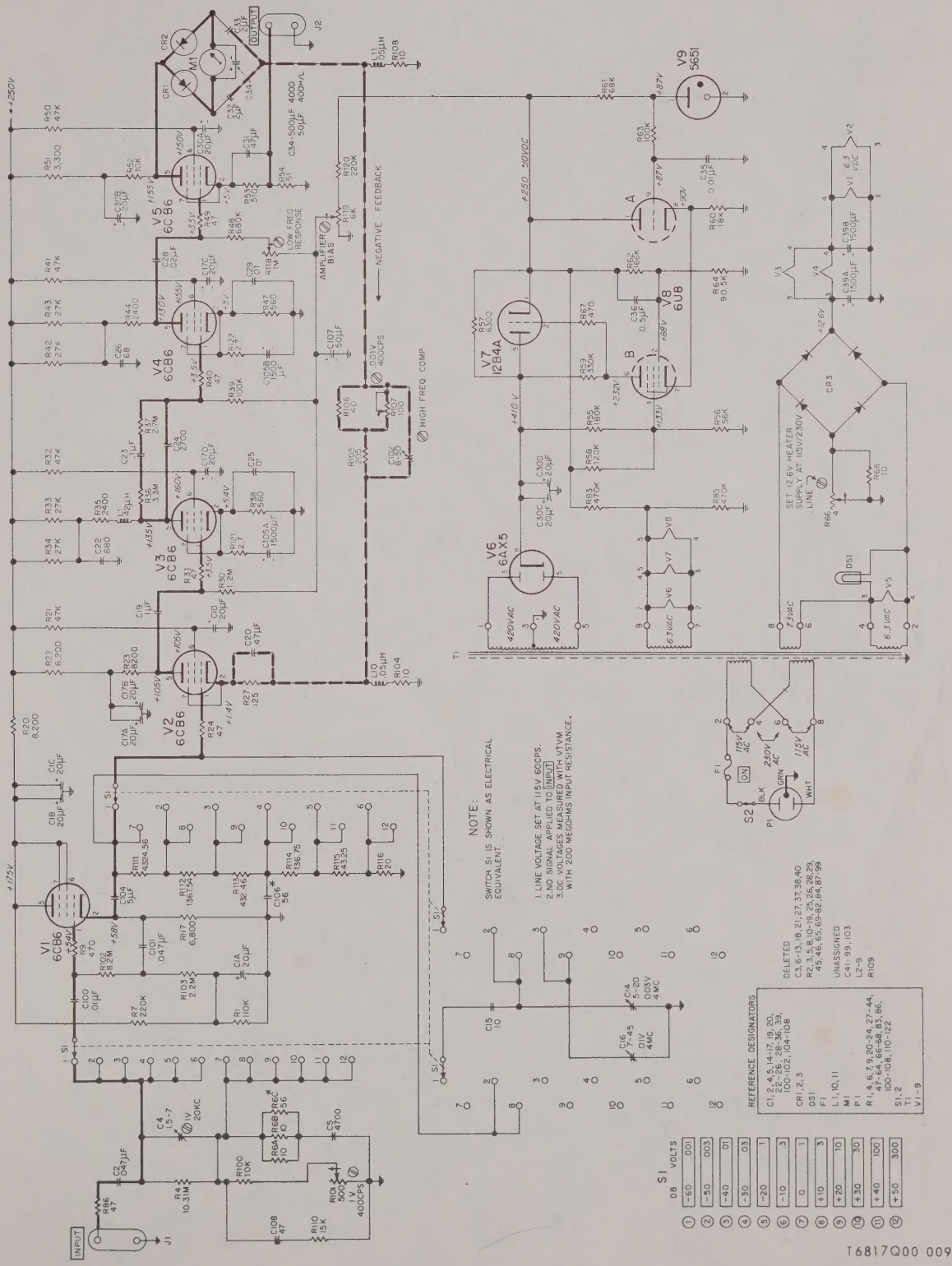


Figure 14-3. Schematic Diagram Models 400D/H/L With Serials Prefixed 017- or 048-

14-13. PARTS DATA CHANGES

14-14. The following table lists the model, serial number, and changes required to modernize these instruments. Listed below is a numerical listing of parts, part numbers, and other data required to accomplish these changes.

Model	Serial Number	Change Number
400D	2221 and below	1
400D	14770 and below (modification kit part number 400D-95A available)	2
400H	1137 and below (modification kit part number 400D-95A available)	2
400D	17970 and below (modification kit part number 400D-95B available)	3
400H	2237 and below (modification kit part number 400D-95B available)	3
400D	25970 and below (with capacitive input divider)	4
400H/L	5225 and below (with capacitive input divider)	4

CHANGE #1 Section VII, Figure 7-2-66
Resistor, Fixed film change to read Resistor, Fixed, metallic oxide film

CHANGE #2 Section VII, Figure 7-5-3
Change Hewlett-Packard part number to read 400D-26B.

Section VII, Figure 7-5-4
Change Hewlett-Packard part number to read 2100-0138.

Section VIII
Change part number 400D-26F to read 400D-26B; change part number 2100-0108 to read 2100-0138.

Section IX
Change reference designator R104 to read R28A; change part number to read 400D-26B; change reference designator R105 to read R28B; change reference designator R108 to read R28C; change part number to read 400D-26B; change reference designator R106 to read R29B; change reference designator R107 to read R29A; change part number to read 2100-0138.

CHANGE #3 Section VII, Figure 7-6-1
Change part number to Hewlett-Packard part number 0160-0005.

Section VII, Figure 7-6
Add Hewlett-Packard part number 0687-1011, resistor, fixed, composition, 100 ohms, ±10%, 1/2 watt; Figure 7-6, add Hewlett-Packard part number 400D-67, resistors, matched set; Figure 7-6-7, change part number to read RC20GF270K, Resistor, Fixed composition, 27 ohms, ±10%, 1/2W.

Section VIII
Change part number RC20GF390K to read RC20GF270K; change part number 160P47396 to read 0160-0005; add part number 0687-1011; add part number 400D-67.

Section IX
Add reference designator R2, part number 0687-1011; add reference designator R3, part number 400D-67; change reference designator R6C, part number RC20GF390K, to read RC20GF270K.

CHANGE #4 Section VII, Figure 5-2-43
Change part number RC20GF561K to read RC32GF101K, Resistor, Fixed, composition 100 ohms, ±10%, 1W

Section VII, Figure 7-5-10
Change part number RC20GF511J to read RC32GF101K.

Section VIII
Change part number RC20GF561K to read RC32GF101K; change part number RC20GF511J to read RC32GF101K.

Section IX
Change reference designators R38, R47, and R53 part numbers to read RC32GF101K

NOTE: Applicable to all models and series of Hewlett-Packard Vacuum Tube Voltmeters

Section VII, Figure 7-5-11
Part Number HD-5004, SEMOCONDUCTOR DEVICE, Diode, add (when exhausted use part number 1901-0027) Figure 7-5-11 add part number 1901-0027, SEMOCONDUCTOR DEVICE, Diode (intchg with HD-5004)

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